Friday March, 23, 1917.

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MOTION PICTURE HANDBOOK

A Guide for

MANAGERS AND OPERATORS *of* MOTION PICTURE THEATERS

By F. H. RICHARDSON

SECOND EDITION

Published by

THE MOVING PICTURE WORLD

Pullman Building, 17 Madison Avenue

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ERRATA.

Attention is called to the following errata. To purchasers of this book it is suggested that the corrections be made on the pages designated, either with pen or pencil, crossing out the incorrect word, letter or numeral, and writing in the margin the correct one given herewith.

Page 20—line 18. Capital letter C, following the words "the standard 48) from," should be changed to a capital E.

Page 57—seven lines from bottom. Should read "Cadmium" instead of "Cadium."

Page 71—next to last line. Should read "is to use" instead of "is to us."

Page 106—last line. Should read "you will not need" instead of "you will need."

Page 110—line 11. Should read "20.05 ohms" instead of "20.5 ohms." Line 12 should read 500 degrees instead of 500 feet.

Page 124—line 9. Should read "in series" instead of "in seires."

Page 200—line 3. Should read "Lamp leads" instead of "Lamp heads."

Page 211—Figure 100 upside down. Although this cannot be changed, attention is called to the error.

Page 339—next to last line. Should read "two feet" instead of "ten feet."

Page 347—Sketch B, Fig. 135. At right hand end letters J and K should change places with each other.

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ADVERTISERS' INDEX

Author's Note

TO FIRST EDITION

THIS book is dedicated to the motion picture operator as a token of appreciation of the important part he plays in the presentation of the photoplay. That it may be helpful in hastening the day of perfect motion picture projection, is the desire of the writer, and he trusts that a careful perusal of its pages may stir the ambition and increase the ability of every reader.

F. H. RICHARDSON.

October, 1910.

Publishers' Note

TO FIRST EDITION

THE remarkable vogue of the motion picture and the rapid strides it has made in public favor as an entertainment and educational factor has had its drawbacks. Chief among these has been the impossibility of securing a sufficient number of men with the necessary knowledge and experience to fill important positions.

THE MOVING PICTURE WORLD has, in no small measure, contributed to the success of the picture and the articles in this book were written to give helpful information in regard to the many problems that may arise in connection with the duties of the manager and operator. With a few exceptions, the articles have already appeared in THE MOVING PICTURE WORLD, but they have been revised and amplified and are herewith presented in compact form to comply with popular request.

Mr. Richardson has avoided technical terms and his plain language and matter-of-fact style bespeaks for this book the same degree of popularity which attaches to the Operators' Column which he still conducts in the pages of

THE MOVING PICTURE WORLD.

October, 1910.

Author's Note

TO SECOND EDITION

LIKE the former edition, this book is dedicated to the moving picture operator, upon whose skill in the projection of the magnificent work of our modern producers, so very much depends. Since the inception of the Projection Department of THE MOVING PICTURE WORLD, and the publication of the first book, rapid strides have been made in the perfection of projection. The author hopes and believes that this work will serve to even further advance and perfect projection to the end that the photoplay may become still more firmly fixed in the affections of the amusement-loving public.

F. H. RICHARDSON.

October 30, 1912.

Publishers' Note

TO SECOND EDITION

THE enormous increase in popularity of the motion picture during the past few years in all countries is one of the marvels of the day. The moving picture is now far in advance of all other forms of public entertainment among all classes and draws a daily patronage that is beyond belief.

In no other country, however, do the pictures have quite as good a hold on the public favor as in the United States. This is in great measure due to the enterprise and higher ideals of the film manufacturers in this country. It is also due in great measure to the care and attention given to programs, theater management and especially the projection of the pictures by the exhibitors throughout the United States and Canada.

The first edition of this work was published over two years since and has been of immense value and help to operators throughout the country. This edition has been greatly enlarged and will be found much more complete in every way. It will undoubtedly remain the standard work in its field for many years and is a worthy monument to its author's ability and painstaking effort.

CHALMERS PUBLISHING COMPANY.

November, 1912.

Introductory Remarks

THE business of exhibiting motion pictures is rapidly settling down to a solid, sound, permanent basis. Theaters better adapted to projection are being erected. There is a constant tendency to improvement in equipment and everything connected with the business. The five cent house is doomed. In its place we will, in the comparatively very near future, have admissions ranging from ten to twenty-five cents—possibly even more. The ten cent admission will probably hold highest favor for some time to come. However, the increase in price will not operate to cut down patronage to any appreciable degree. On the other hand it will enable managers to present a far better show, at the same time reaping larger financial reward for their efforts.

The day of shadowy, jumpy projection is passing. Better results are demanded by the public, and that demand must be reckoned with. It is being heeded, even now, and the exhibitor who fails to read the writing on the wall, and keep step with the march of progress, will very soon find himself hopelessly outclassed. He will be a back number in the exhibition business and will be compelled to retire in favor of those willing and able to keep abreast of the times.

For a time the effort was made by many managers to substitute quantity for quality. Some managers even went to the extent of running seven to nine reels per show, changing daily. The net result was confusion worse confounded. The craze for quantity has about run its course, and had its day. Together with other equally fallacious ideas it has been, or is rapidly being, relegated to the limbo of forgotten dreams, where it rightly belongs. Quality is the slogan for the future.

The wise manager will recognize the change being wrought and bend every energy to improve his programmes by careful selection, arrangement and excellence in projection. He will install all reasonable conveniences and comforts for his patrons. He will use every care in the selection of music for his pictures, and will study deeply the matter of advertising.

The motion picture theater musician also must realize that the crude (and how very crude some of it was) work of the past will not serve for the future. Music means very much to the picture. By proper selection and careful rendition, it may add amazingly to the value of certain scenes, or it may utterly ruin the same scenes if the selection or rendition be carelessly done. The musician must understand thoroughly how very much depends on his or her efforts, and act accordingly.

The operator of the past is not the operator of the future. Time was when motion pictures drew crowds simply by reason of their novelty. They can do this no longer. Time was, and not so long ago, when appliances were crude, films were poor in photography and miserable in perforation. Time was when the operator was only supposed to know how to turn the crank and splice a film after a fashion. Time was, and not so long ago, when the operating room was a "coop," put anywhere there was space, within sight of the screen, which could not possibly be used for any other purpose. Anything was good enough for the operator. He was supposed to be only half human.

But this state of affairs is also undergoing rapid change. It is beginning to be recognized as a fact that brains are necessary in the operating room if high-class results are to be produced on the screen. Managers are beginning to understand that it is useless to expect excellence in results from a little iron lined "coop" stuck up in one corner of the theater. They are awakening to an understanding of the fact that a good operating room, amply ventilated and equipped with the very best projection machinery to be had, in charge of a man of resource and ability, is a good investment from the dollars and cents point of view.

It follows that the demand for men well equipped with projection knowledge is growing day by day. It is becoming apparent that, in the near future, the operator who fails to equip himself with adequate knowledge of his profession, will have to step down and out, giving way to others who, recognizing the signs of the times, have done so. The operator must, and the real operator will, make a systematic study of his art in all its branches. He will use every endeavor to place flawless projection on the screen. He must remember that in every walk of life it is those who put brains, rather than brawn, into their work who receive adequate remuneration. Perfect projection is far more the direct result of mental effort on the part of the operator than it is of the work of his hands.

Operators must receive larger salaries. First, however, they must be able to produce better results on the screen. The sectionman on a railway receives about a dollar a day. He is not likely, even with the help of organization, to receive very much more. Why? Simply for the reason that any one with physical strength to do it can tamp a tie and shovel dirt as well as the next man. The operator of the past has received from six dollars a week up. The average was probably below fourteen dollars. Why? Mainly because good work was not in demand and almost anyone could supply the class of projection which lack of knowledge on the part of the managers made acceptable. But managers are learning that better things are possible, as also is the public. Shadowy rainstorms are being rapidly relegated to the lumber-room of the past. Real projection is more and more the demand. The finer points of projection are becoming better understood by the manager and he wants their results on his screen. Not every one can put them there. That may only be done by those who have made a study of their profession and have real knowledge of all its branches. It naturally follows that this restricts the field, and that salaries are bound to rise, aside from any question of union organization. It also follows that the operator who is satisfied to remain in ignorance, refusing to study and perfect himself in his chosen field of endeavor, will soon find himself left hopelessly behind in the race.

This book is designed to offer both managers and operators, as well as all those connected with the motion picture theater, real, genuine instruction in all branches of the exhibition end of the business. When published it will be up to date and will, in conjunction with the Projection Department of the Moving Picture World, edited by the author, keep one fully posted and abreast with the times.

Electricity

THE very foundation stone of the motion picture business is light. It is, therefore, appropriate that it be the first subject considered.

Let it be clearly understood that this is a book for practical men. It is for men of to-day. Therefore we shall not go back and expend valuable space in explaining the practices of early days when stereopticon projection was accomplished by means of coal oil lamps. That, while of interest as a curiosity, is of the past. The projection light of to-day, except for the comparatively very few cases when gas is used, is the product of the electric arc; the most powerful illuminant known to science.

It is not only necessary, but absolutely essential to excellence in results, that the operator possess a good working knowledge of the action of electric current, and of the various electrical appliances he is obliged to use in connection therewith. He is called upon to handle quite a number and variety of electrical devices, as well as different systems of electric wiring. He must thoroughly understand them all, not only mechanically, but electrically as well.

Exactly what electricity is, no man knows. It is only visible in the form of heat, which means, of course, light. We can only feel its action in the form of heat and through the medium of a more or less unpleasant shock. It has no weight, and seemingly no substance, at least in the accepted sense of that term. We are, however, able to measure and calculate accurately its power to do work. We are able to determine precisely what it will do, and how it will act under almost any known circumstances or conditions. The best definition of electricity the writer has ever heard is as follows:

Electricity is a peculiar quality in a wire attached to a dynamo or battery, not present in any other wire.

Electricity is divided into distinct classes, such as magnetism, static electricity, etc., each having widely different characteristics. The motion picture operator has, however, comparatively slight interest in static electricity or magnetism. His work is most entirely with the electric current produced by what is called a dynamo or generator, which consists of an armature, and a field magnet. The armature has a shaft upon which is mounted an iron core, and, at one end of the core, a series of bars or rings called a commutator. Upon the core are wound many coils of copper wire, the ends of which are attached to the commutator bars. This constitutes what is known as the "armature" of a dynamo. It revolves between, and in close proximity to one or more powerful electro-magnets, between or around which pass what are termed lines of magnetic force.

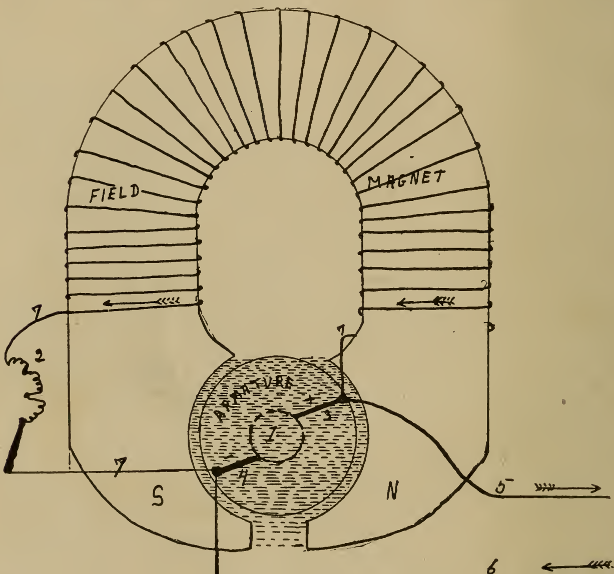


Fig. 1.

Briefly, electric current is produced by copper wires, wound on an iron armature core, cutting lines of magnetic force. The dynamo depends for its action on the following law:

If an electrical conductor, a wire for instance, be moved in a magnetic field, a current of electricity will be generated.

In Fig. 1, we see an armature, a commutator, and two field magnets, N. and S. Between these magnets (really the two poles of one magnet) are passing lines of magnetic force, as indicated by the horizontal dotted lines. As the armature is revolved, its wires, wound lengthwise thereon, cut through these lines of magnetic force. A current of electricity is thus generated, the strength of which depends on the number of wires on the armature, the speed at which the armature revolves and the strength of the magnetic field. This current flows from the armature wires into the commutator, thence into brush 3 and out on line 5, around the circuit, passing through the lamps, motors, etc., to line 6 and back to the armature through brush 4. A small amount of the current generated flows around field circuit 7-7. It is this current which excites the magnets and creates the magnetic field, the strength, or density of which will depend on the amount of current flowing through the field circuit. The amount of flow in field circuit 7-7 is governed by field rheostat 2. This type of generator is called a "Shunt Wound" machine.

Very crudely and briefly, taking no account of the many variations of the principles thus set forth, this is the action of the electric dynamo, or generator. There are many types and kinds of dynamos, but all depend on the principle set forth for their action. Those interested in studying generators will doubtless find any number of standard works on dynamo construction in their public libraries. Such study will be found of much interest and value.

Noted experts in matters of electricity do not by any means all agree as to the action of electric current. There are those who claim that nothing in any way equivalent to volume, or quantity, passes along or through the wires. There are those who claim that electric action consists wholly in a sort of molecular bombardment. There are also those who claim that volume—quantity—flows along, or through the wires. Such arguments are technical in the extreme. They are of slight practical interest to the ordinary workman. Personally the writer does not believe the man lives who knows what actually does take place. For the purposes of this work, however, we shall assume that current flows along the line, just as water flows through a pipe, and shall speak of it thus.

DIRECT AND ALTERNATING CURRENT

Direct current, familiarly known to electricians as "D. C.," is thus named for the reason that it flows constantly in one direction. With D. C., one wire of the circuit is constantly positive, the other constantly negative. The current, or electric impulse, is supposed to flow out from the positive dynamo brush, and along the positive wire of the circuit. At each lamp, motor or other device consuming current a portion escapes through the device to the negative wire, and is by it conveyed back to the dynamo. D. C. is seldom found above 500 volts pressure for the reason that above figure it is difficult to effectively insulate the commutator bars from each other. After leaving the dynamo the voltage of direct current cannot increase without the use of machines with moving parts, which is expensive and impractical. D. C. is, however, far superior to alternating current for projection purposes, for reasons explained under "Carbon Setting," Page 202.

Alternating current, commonly known by the abbreviation "A. C.," is a much more complicated problem. It is very largely used by light and power companies. This, for several reasons, the main one being the fact that it is readily generated at high pressures and may be "stepped up" to a still higher voltage, or reduced to lower voltage, after leaving the dynamos, by means of a very simple device called a transformer, which has no moving parts and requires practically no care or attention. This, as has been said, is not so practical with direct current.

The advantage in high voltage comes from the fact that while a wire of given size will carry a certain, definite number of amperes of current, and no more (see table I, page 32), it will carry those amperes at any voltage. Electric energy — the ability of the current to do work — is measured in watts. One watt is equal to 1/746 of a horsepower. It, therefore, follows that 746 watts equal one h.p. Watts are found by multiplying the volts by the amperes, thus: 10 amperes at 110 volts = (10 x 110) 1,100 watts. Horsepower equals volts multiplied by amperes divided by 746. Referring to wire table I, page 32, we see that a No. 6 wire, rubber covered, must not be allowed to carry more than 46 amperes of current. Now suppose we have a No. 6 wire carrying 46 amperes at 110 volts; $110 \times 46 \div 746$ gives us approximately 6¾ horsepower as the limit of electrical power we can convey on a No. 6 wire at 110 volts pressure. Now suppose we have the same 46 amperes flowing on the same No. 6 wire, at 2,000 volts pressure. We now have $2{,}000 \times 46 \div 746$ = about 123 horsepower, now being conveyed over a wire which was loaded to rated capacity with less than 7 h.p., when the pressure was 110 volts. You will thus readily see the enormous saving in copper (wire diameters) by high voltage. This is especially important if the power (current) is to be conveyed any considerable distance. To convey 1,000 horsepower one mile at 110 volts pressure would require heavy outlay for wires of very large size. By use of high voltage this cost is immensely reduced. I have dwelt upon this somewhat for the reason that the operator should have a general knowledge of such matters.

Alternating current, unlike D. C., does not flow continuously in one direction. Quite the contrary, it flows first in one direction and then in the opposite direction, the period of flow in either direction varying from 1/50 to 1/120 of a second. It then reverses itself and flows in the opposite direction for an equal space of time. Two of these periods of flow are called a "Cycle." Where light only is produced, the current frequency (number of alternations per second), is sometimes quite high. It runs as high as 133 cycles (266 alternations) per second, but there are comparatively few of such plants now in existence.

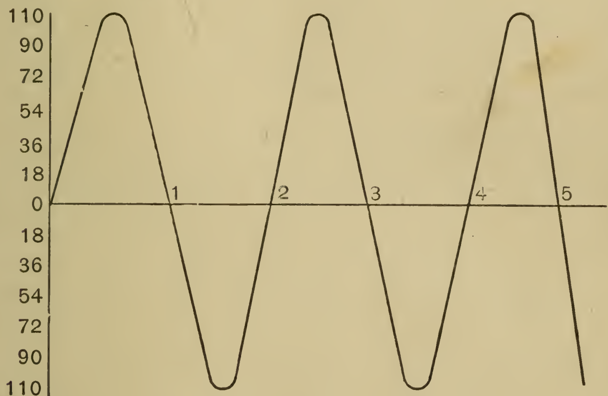


Fig. 2.

Is is essential that a clear understanding of the action of A. C. be had. This action is usually expressed as in Fig. 2. In this diagram the horizontal, dotted line represents the point of zero, or no voltage at all; it also expresses, in its length, time. The vertical column of figures indicates voltage. Remember the fact that A. C. reverses its direction constantly, flowing first in one direction and then in the other. We will take sixty cycle current for example. Each cycle represents two alternations. Therefore since there are sixty cycles in one second there would be $60 \times 2 = 120$, alternations in the same time. To make the matter clearer, suppose you walk across a room and then turn around and walk back. When you get where you started from you will have completed a movement corresponding to one cycle. If you could walk across the room in 1/120 of a second, turn and come back in the same period, and do that sixty times in one second, you would be doing exactly what alternating current does.

I am fully aware of the difficulty the average man has in understanding diagrams, such as is shown in Fig. 2. I shall, therefore, try to make it very plain and simple. Fix firmly in your mind the fact that it requires two alternations to complete one cycle and, with 60 cycle current, one complete cycle occupies 1/60 of a second of time. Understand that at the instant of alternation (when the current reverses its direction), there is no voltage (I deal with single phase current now) at all; therefore, no amperage or anything else. Both current flow and voltage are at zero. The dotted, horizontal line represents the point of alternation — the point where the current changes direction. When an alternation starts, the voltage and amperage start to rise, gradually increasing up to maximum in a period of time representing one-half the alternation, or 1/240 of a second. It then gradually again falls during the next 1/240 of a second to zero.

Remember that, rapid as is the action, it is nevertheless relatively gradual. The V-shaped lines above and below the dotted line represent the rise and fall in voltage, according to the upright scale at the left. Now, fixing the foregoing facts in your mind, take in either hand a pencil. Place the point of each at 0, on the zero horizontal line, and run one point around the first upper curved triangle, at the same time moving the other pencil point straight out along the dotted line to 1, causing both actions to take place in exactly the same time, so that the pencil points meet at 1 at the same instant. The pencil point moved out along the dotted line represents time. The other represents the rise and fall of voltage during the time the current is flowing in one direction. During the time the pencil has moved from 0 to 1, one one-hundred-and-twentieth of a second has elapsed, the current being 60 cycle. In the same period the other pencil has traced the current line, or line of pressure. Starting at zero, or nothing, it rises to maximum, 110 volts, and falls again to nothing and the amperage rises to maximum also, and again drops to zero as the pencil reaches 1. If we continue the first pencil on out to 2, while the second traces the lower triangle to the same point, we shall have completed one cycle and the current will have again started at zero, risen to maximum, and again have fallen to zero. The distance from 0 to 1, 1 to 2, 2 to 3, and 3 to 4, each represent 1/120 of a second, while the triangular lines represent the pressure at each point of time during the alternations, as shown by the figures in the vertical column. This is as clear as I am able to make the matter, without using technical terms, and I trust the reader will be able to grasp the idea.

It necessarily follows that each wire of an A. C. circuit is alternately positive and negative, and it is this which makes the current poor for projection, as will be seen under the chapter headed, "Carbon Setting." The reversals of the current are due to the peculiar construction of the dynamo, a matter hardly necessary to include into this work. Those interested may easily consult standard works in their local public library.

The alternating current commonly encountered is 60 cycle. At Buffalo, N. Y., and elsewhere, near great water power stations in which vast energy is generated and used mostly for power, current frequency as low as 25 cycle (the most economical for power) will be found. In small towns where practically all current is used for light, the frenquency may be as high as 133 cycles per second. The reason for this lies in the fact that low frequency is most economical for use in motors, while high frequency is best for light. Experiments have shown, however, that 60 cycle current produces excellent light, while at the same time it is fairly economical for power. It has, therefore, been adopted as the standard by practically all plants furnishing both light and power.

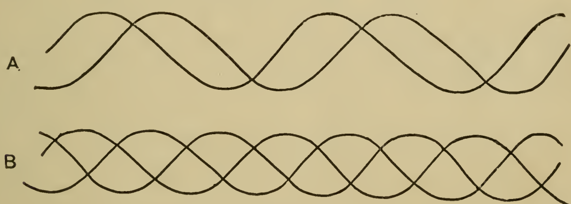


Fig. 3.

Still further complications arise in handling A. C. from the fact that it has several variations. Besides ordinary single phase alternating current we have that known as two and three phase current. It is unnecessary that the operator go very deeply into these matters, however. Beyond understanding the practical meaning of the terms he need know very little about them, although it is true that the broader knowledge he has of such things the better off he will be. In Fig. 2 we have studied the meaning and action of ordinary single phase A. C.

If we now couple the armature shafts of two A. C. generators so that they are rigidly connected, and in such manner that when the current of one is at zero voltage the other is at maximum, we shall then have what is known as two-phase current. This is illustrated in Fig. 3-A.

If we now couple three dynamos, each exactly like its mate, in such manner that their current values rise and fall as shown in Fig. 3-B, we will have three-phase current.

Two-phase current usually employs four wires (two separate circuits) for its distribution. Its advantage lies in the fact that the two currents, acting like the pistons of a double engine, give a steady pull, instead of an intermittent one, on the armature of motors. It has no advantage in lighting. Three-phase current requires but three wires for distribution. It is the ideal system for transmitting electrical energy long distances for power purposes. It gives a practically steady pull on the motor armature. There is still a fourth system called the Monocycle System, in which two wires transmit the energy, while a third wire serves to excite the field of the motor in starting. This system is used with what are termed "induction motors." In actual practice a two and three-phase circuit is produced, not by separate generators coupled together, but by an arrangement of the field and armature coils of a single machine.

STEP OR SYNCHRONISM

Electricians sometimes speak of generators remaining in "step" or in "synchronism" with each other. This means that they have their shafts coupled so that the current values must rise and fall constantly in relation to each other, as shown in Fig. 3-A and B. To produce two or three-phase current the rise and fall of current pressures must remain absolutely in step or synchronism with each other, as will be readily seen. Once you have grasped the real meaning of the Fig. 2 diagram, it will be easy to understand the rest. Therefore study Fig. 2.

POLARITY

To obtain an adequate comprehension of the electric current, one of the first and most essential things to understand is the true meaning and effect of polarity, since it is on this the whole fabric of electrical energy and action rests. An electric circuit, such as the operator has to deal with, is always formed by two wires. There are never more — there cannot possibly be less. There may appear to be more, as in the three-wire system, but summed down it is found that, so far as current action be concerned, there really are but two. There is one exception to this in the series arc system, but with it the operator has nothing to do. There is another exception in the monocycle system, in which a third wire is used for motor field exciting, but this system is used wholly in connection with induction motors.

The two wires represent the two poles of the dynamo. They are similar in their action and affinity for each other, to the N and S poles of a magnet. As to what really does take place, as between the two wires of an electric circuit, there exists, as has been said before, argument even among noted theoretic electricians. The matter is still open to question. To avoid confusion by entering into such questions of theory we will accept the common statement that the current seeks always to flow from positive to negative. Positive electric energy seeks constantly to escape from the postive wires to the negative. Its inclination to do so is so great that it will perform work, and lots of it, in the effort to get from one wire to the other. I am not, in these things, seeking to adhere strictly to technical correctness. I am trying to convey an idea, and convey it clearly. If I succeed in enabling you to grasp the main idea, technical correctness will come later.

The strength of this electrical affinity of one wire for the other is termed voltage. It represents electrical pressure, and seems to be in its action in every way analagous to pressure in steam, water or any other fluid or gas. It stands for the difference in potential between the two wires.

At this point let me correct a wrong and very general impression — one that the writer himself held for a long time, viz: that this affinity not only exists between the two wires of a circuit, but also between the wires and the earth. This is not the fact. Electrical affinity exists only between the two poles of a dynamo, and the wires attached thereto, termed the negative and positive. There is absolutely no affinity whatever between the wires and the earth, except as it, the ground, offers electrical conductivity between the two wires of opposite polarity attached to the same dynamo. If the dynamo itself be thoroughly and completely insulated from the earth and the negative wires of its circuit be also completely insulated at every portion of their length you could stand directly on wet ground and handle the positive wire of that generator with perfect safety, even though charged with 10,000 volts pressure. If the positive be completely insulated you could handle the negative with equal impunity. As a matter of fact, however, the wires of a light or power system are seldom or never completely insulated. Some systems are purposely grounded. I have set this forth to show that electrical affinity is between the wires attached to the opposite poles of a dynamo only.

ELECTRICAL TERMS

He who handles current ought by all means to be conversant with the meaning of certain terms which are in constant use. Some of the definitions I shall give may not be exactly theoretically correct. We are not, however, dealing with fine-spun theories. The definitions are thoroughly practical, and from the practical point of view are correct. They will pass muster among practical men.

Voltage.—I have told you that voltage represents the strength of the affinity between the two wires of a circuit. Theoretically, this is absolutely correct. In practice, however, we consider it and treat it as pressure. It is exactly similar to the pressure of steam in a boiler, or of pressure in a water pipe. The ordinary dry battery, such as is used for bells, has a pressure of about one volt. It imparts that pressure to wires connected to its poles. Now if you attach two wires, one to each pole of a battery, those wires, at any portion of their length, will have a pressure of one volt. If you now attach a second similar battery to these same wires in "series" with the first, the pressure will be two volts. A third will raise the pressure to three volts, etc. Instead of the battery, the dynamo is used for light and power purposes, which produces any voltage up to 500 D. C., and any voltage up to say, 6,000 A. C., according to how it is constructed. Each dynamo is built to produce one voltage and one voltage only, regardless of the volume of current it puts out.

Ampere is a term used to denote quantity. It represents the amount of current passing through a wire, just as gallons stands for the quantity of water flowing through a pipe. As between the volt and ampere it is really the volt pressure which does the actual work, though without amperes no work could be performed.

This is the point which creates a muddle in the mind of the average man. I shall try to offer adequate explanation; a matter I have never yet seen in print.

When a 16 c.p. 110 volt incandescent lamp burns at candlepower there is approximately ½ ampere flowing through its filament. With less its c.p. immediately drops; with more it rises. We jump to the conclusion that the ampere does the work. In a way it does and yet it does not. It is the pressure forcing a certain quantity through that does the actual work. Let water be supplied to a pipe without pressure. It may flow, but will perform little or no work. Supply pressure and the capability for work is there instantly, this capability being largely dependent on the amount of pressure. True the water will do some work without artificial pressure because of its gravity pressure, or weight. The current has no weight — no gravity pressure. It is, therefore, entirely dependent for its action on artificial pressure. I believe, therefore, we may say that volume is merely the vehicle through which pressure works, and that the result is attained through a combination of the two, the voltage doing the actual work, it being the thing consumed, not the ampere. Steam is not consumed in the cylinder of an engine. Water is not consumed in a water motor. It is the pressure which is consumed, and which does the actual work. However, it is the steam pressing against the piston head (pressure working through the medium of steam) that causes the head to move, and the larger the cylinder the more steam will be required, though at the same pressure, and the larger the piston head the greater amount of work will be performed with a given pressure. It is the water pressing against the blades of the water motor (pressure acting through water) which causes the motor to revolve. The larger the motor the more water will be necessary, though it may be at the same pressure. To get more power it is necessary to have either more pressure or more water or steam — a larger volume for the pressure to work through. The analogy holds good with electric current. To get a given amount of work with a low pressure (voltage) large quantity (amperage) is necessary. If the voltage be high an equal amount of work may be performed with small amperage. However, if a man had a boiler supplying 150 pounds pressure, and had a 40 h.p. engine he would not ordinarily raise the boiler pressure to get more power. He would, instead, install a larger engine — one using more steam. In electrics, as with the steam plant, we usually have a standard, unvarying pressure, or voltage. If a lamp does not produce sufficient light for our purpose we do not raise the voltage but install a larger lamp — one using greater amperage.

Ohm is the term applied to the unit of electrical resistance. It is used to measure the resistance met by the current in its passage through a wire, or other conductor. Water in flowing through a pipe encounters resistance, both within itself and by reason of the rough sides of the pipe. This resistance retards the flow and increases as the volume of water passed through a pipe of given length and diameter is increased. Resistance generates heat, though in the case of water it is not sufficient to be noticeable. What is true, in this respect, of water in a pipe, is also true of current in a wire, and the resistance encountered is measured in ohms.

Watt is the term used to measure the amount of electric energy expended — to measure the actual work performed.

Watt-hour is the term used to designate the amount of electrical power expended through the use of a watt for one hour of time. Thus: An ordinary 16 c.p. 110 volt lamp consumes about 55 watts, hence in one hour would use 55 watt-hours.

Kilo-watt is a term of convenience, meaning 1,000 watts.

DEFINITION OF TERMS

Most of the definitions given in standard works on electricity have their meanings hidden in a multiplicity of words, to such an extent that the ordinary man can scarcely decipher the real meaning. Other writers couch their definitions in such technical language that they are utterly worthless to any except the trained electrician. The definitions of electrical terms given in my former handbook are still the plainest and best I have been able to discover. They are therefore repeated.

These definitions are the clearest, simplest, the writer has been able to discover after a search of many standard works on electricity. He believes that a close inspection of them will enable the average man to arrive at a pretty close understanding of what the terms really mean. At any rate they cannot, I believe, be put in simpler language.

Volt.—The practical unit of electric pressure, or electro-motive force. The pressure required to move one ampere against a resistance of one ohm. The electro-motive force induced in a conductor, usually an armature coil, which is cutting 100,000,000 magnetic lines (of force) per second.

Ampere.—The unit of electric current (quantity or volume). That amount of current which can be driven by a pressure of one volt, the unit of electric pressure or electro-motive force, through one ohm, the unit of electric resistance. Such a rate of flow of electricity as would transmit one coulomb per second (a coulomb is defined as the unit of electrical quantity. That quantity of current which would pass in one second through a resistance of one ohm, under a pressure of one volt.) A current of such strength as would deposit .005084 grains of copper per second. The unit rate of flow per second.

NOTE.—Some writers say that the term ampere does not represent quantity, but only indicates the strength of the current; quantity being represented in coulombs, which means the quantity passing a point in a given time (coulombs equal the amperes times seconds). This is splitting hairs altogether too fine for the average operator. Technically the above statement is quite true, but for the operator's purpose it is well enough to say that amperes represent quantity.

Ohm (There are several standards, viz., the Board of Trade Ohm, English Ohm, British Association Ohm, Legal Ohm and the Standard Ohm.)—The "Legal" ohm is the standard used in the United States, and it is defined as follows: The resistance of a column of mercury (the resistance such a body of mercury would offer to current) 106 centimeters in length, having an area of cross-section of one square millimeter at 0 degrees Centigrade, or 32 degrees Fahrenheit. This is now the international value of the ohm.

Watt.—The unit of electrical activity or power. The number of watts is numerically equal to the amperes times the voltage. One volt times one ampere equals one watt, or 1/746 horsepower. Sometimes called the "Volt-Ampere."

HOW TO USE THE TERMS IN CALCULATION

It is an open question as to just how much practical use the operator will be able to make of the terms in calculations, since to find one quantity by calculation it is necessary that two others be known. To calculate the number of amperes flowing through a given resistance one must know accurately the number of ohms the resistance offers and the voltage of the current. To find the resistance in ohms, the exact amperage and voltage must be known, and to determine the voltage by calculation the exact ohmic resistance and amperage flowing is necessary. One quantity is usually known definitely, viz: Voltage. In the operating room, however, the exact amperage or ohmic resistance is seldom a matter of accurate knowledge; nor may they be readily determined. Nevertheless, the operator should know how to make calculations, even though ordinarily he be unable to apply the rules with precision.

In making calculations the operator must understand that, when his arc light circuit is in question, the resistance is not wholly in the rheostat, or whatever takes its place. A small portion is in the wires, lamp-arms and carbons, and a very considerable portion is in the arc itself. Unless this fact be taken into consideration, serious error will result from any calculation.

In expressing electrical formulas it is customary to use the letters E, C, and R. These letters are used merely for the sake of brevity, and E stands for electro-motive force, which is but another name for voltage. Hence E stands for voltage. C stands for current, meaning amperes. R stands for resistance, as expressed in ohms. Let it be remembered that in a fraction the horizontal line always means "divided by," thus: ½ really means $1 \div 2$. E/C means that the quantity represented by E is to be divided by the quantity represented by C (amperes). If two or more quantities are above or below the line, with no sign between them, it means that they are to be multiplied together; thus: $\frac{E}{C R}$ means that E (volts) are to be divided by C x R (amperes x ohms). $\frac{E-15}{C}$ means that after 15 is subtracted from the quantity represented by E (volts), it is to be divided by the quantity represented by C (amperes). It will greatly assist the student if he will practice substituting the various quantities for the letters, fixing the meaning of the latter firmly in his mind.

Ohm's law says that the number of amperes flowing will equal voltage divided by resistance, in ohms. Hence we have $\frac{E}{R} = C$ (Volts divided by ohms equal amperes). It follows that if E divided by R = C, then C x R must equal E. It also follows that $\frac{E}{C} = R$. It works out as follows: We know that the ordinary 110 volt, 16 c.p. incandescent lamp carries approximately ½ ampere of current. What is its resistance? We have the formula $\frac{E}{C} = R$. Substituting figures for letters we have $\frac{110}{.5} = R$. 110 divided by .5 = 220, the number of ohms resistance in the filament of the lamp. Applying the formula $\frac{E}{R} = C$ we divide 110 by 220, and have .5 or ½ as the amperage.

All that is simple enough of understanding and application. When, however, we come to apply the formulas to the projection arc light circuit we encounter another equation. We must then, as has been intimated, take into account the resistance of the arc itself. Also, to be absolutely accurate, the exact resistance of carbons, lamp-arms, and wires must be considered. In practice, however, this is seldom or never done, by any but the expert electrician.

In leaping the air-gap between the carbon tips the current encounters high resistance. In overcoming resistance, voltage is always consumed, as will be more thoroughly explained under Wiring. In other words, when current flow is opposed by resistance, and that resistance is overcome, there is a consequent drop in the pressure, or voltage. Pressure has been used, or consumed, in the process. The resistance of the arc, consequently the voltage drop in overcoming its resistance, is proportional to (a) length of the arc, (b) size and character of carbons, (c) kind of core, (d) number of amperes flowing. All these factors enter into the equation, but largely the resistance is proportional to the length of the arc.

For reasons not necessary to enter into at this time the D. C. arc, for a given amperage, is longer than the A. C. arc. It, therefore, follows that its resistance will be higher. The accepted theory is that all voltage is consumed at the arc. Whether or not this is true is a highly technical question, which it would be unprofitable to discuss in these pages. We shall accept the theory. Therefore the rheostat, or whatever takes its place, must cut down the voltage to just that pressure which the resistance of the arc will consume when burning normally.

When an ordinary D. C. projection arc is operating at its best it consumes about 48 volts. The arc voltage varies from 45 to 55, but 48 is a fair standard. In other words the current must reach the arc at that pressure, and that pressure will be consumed in the arc. Ordinarily it is spoken of as "48 volts drop across the arc." What is the resistance of such an arc operating at 40 amperes? Knowing the voltage (48), and amperage, we apply the formula $\frac{E}{C} = R$, and have $48 \div 40 = 1\ 1/5$ ohms; arc resistance.

Let us prove this out. Suppose the line voltage to be 110. The total resistance must equal ($\frac{E}{C} = R$) the voltage divided by the amperes flowing; therefore, the amperage being 40, the resistance must be $110 \div 40$, or $2\frac{3}{4}$ ohms. We have seen that the arc resistance is $1\ 1/5$ ohms with its voltage at 48. Subtracting the arc voltage from the line voltage leaves us 62, as the drop in voltage there must be across the rheostat. Again applying the formula ($\frac{E}{C} = R$), we have $62 \div 40 = 1\ 11/20$ as the ohmic resistance of the rheostat. Adding this and the arc resistance, together, we have a total of ($1\ 1/5 + 1\ 11/20$) $2\frac{3}{4}$, as the total resistance, which we see is correct. It corresponds to the total resistance necessary to allow 40 amperes to pass through.

If the amperage were 45 then the total resistance, voltage remaining the same, must be less. If the amperage were less, then the resistance would necessarily be greater. The higher the voltage the greater must be the resistance, as will be seen by applying the formula $\frac{E}{C} = R$, to accomplish a given current flow. Resistance is always found by application of the formula last quoted.

Arc resistance, as we have said, will vary somewhat, according to the character of carbons and cores, the amount of current flowing and the arc length, particularly the latter. However, with the D. C. projection arc we are reasonably safe in taking the constant 48, for the arc drop, or arc voltage, unless the amperage is low—say 30, or less, when 50 will serve better. Such a standard is necessary, even though more or less inaccurate, since the operator seldom has a volt meter with which to measure the arc voltage exactly. Instead of applying the formula $\frac{E}{C} = R$, as it stands, we first subtract the arc voltage (using the standard 48), from C, which represents the line voltage, thus securing, at one operation, the total resistance other than that of the arc. The problem then reads, for any D. C. arc above 30 amperes, $\frac{E-48}{C} = R$, but the "R" in this case is the necessary ohmic resistance except that peculiar to the arc itself. In subtracting 48 we have accounted for the arc resistance. For an arc of 30 amperes, or less, the formula is $\frac{E-50}{C} = R$. For the ordinary A. C. projection arc, up to 60 amperes, the formula to be used is $\frac{E-35}{C} = R$. In other words, we use 35 as the A. C. constant for arc voltage, instead of the 48 used for D. C.

Suppose we wish to construct, or order a rheostat to deliver 25 amperes on 125 volts line presure, when working in series with a D. C. projection arc. We use the formula $\frac{E-45}{C} = R$. Substituting figures for letters we have $\frac{125-45}{25}$, which equals the necessary ohmic resistance of the rheostat, not taking account of line and carbon resistance. $125 - 45 = 80$ and $80 \div 25 = 3\ 1/5$, the number of ohms resistance the rheostat must contain. If it were a 40 ampere arc we would subtract 48 instead of 45. If it were an A. C. arc we would subtract 35.

Were we to connect the same rheostat between the wires of a circuit carrying the same voltage without an arc in series, with, or, what amounts to practically almost the same thing, freeze the carbons of the arc lamp, we would then find the 3 1/5 ohm rheostat, which delivered 25 amperes in series with an arc, to be delivering $(\frac{E}{R} = C)$ 110 ÷ 3 1/5 = 34.4 amperes, almost.

RULE OF THUMB

There is a very simple formula, easy of application, which combines the three formulas into one. It is called the "Rule of Thumb." It is expressed for general use as: $\frac{E}{C\,R}$.

To use the formula you have but to cover up the symbol, or letter representing the quantity desired, and what remains will produce the answer, thus: Suppose we wish to ascertain the resistance in ohms. We cover up the "R" in the formula and find that we have $\frac{E}{C}$ remaining, which will give R, the desired quantity. In using this formula on projection circuits the top letter must be expressed as E minus the arc voltage, the same as in the regular formulas, thus:

$$\frac{E-48}{C\ R} \text{ or } \frac{E-45}{C\ R} \text{ for D. C. and } \frac{E-35}{C\ R} \text{ for A. C.}$$

FINDING WATTS AND HORSEPOWER

Watts represent the power produced — the actual work done. To find the watts you multiply the number of amperes flowing by the line voltage, thus: 50 amperes at 110 volts = (110 x 50) 5,500 watts, or (5,500 ÷ 1,000) 5½ kilo-watts, commonly expressed as 5½ k.w.

In horsepower this amounts to (746 watts equal one h.p.) $5{,}500 \div 746 = 7\frac{129}{375}$ h.p. Remember that line voltage by amperes equals work done, regardless of amperes or voltage at the arc. When a rheostat is used, a large portion of the voltage is used up in the resistance, but it must be paid for just the same. Where a transformer is used, the amperage at the arc is usually very much greater than that taken from the line, but it is the latter, at line voltage, which counts. See "Transformers."

Wiring

IT is by no means necessary that the operator, or manager, be a practical wireman in all that term implies. It is, however, imperative that at least a fair working knowledge of the underlying principles of electric wiring be had, particularly by the operator. It is desirable that he have a fund of knowledge sufficient to enable him to not only thoroughly understand the wiring problems of the operating room, but, if necessary, to do the job himself, and do it right. Operators in the smaller towns, and on the road, are often obliged to do these things, if they are to be done at all. In fact, the road operator — that is to say the man with a traveling show — has urgent need of a very complete fund of knowledge concerning electrical action and wiring as applied to the projection circuit. He must understand how to "hitch up" to all kinds of wire systems, switchboards, panel boards, etc., and to all pressures up to say 550 volts. He must be able to accurately ascertain of the capacity of wires, meters, transformers, etc. He must be able to tell from a hasty examination whether or not connecting up in any certain way will be permissible and perfectly safe. In fact, the road operator is frequently called upon to perform feats which might well puzzle pretty good electricians.

The ordinary, stay-at-home operator encounters few of these problems, but he should, nevertheless, possess knowledge requisite to cope with them, since one can never tell when need may arise. In any event the more he knows about electrical action, wires and wiring, the better.

Electrical action through wires is, as has already been said, in many ways very similar to the action of water under pressure, through pipes. If we have a water pipe one inch in diameter, it will carry water up to its capacity (which is the point where friction becomes excessive), under any pressure less than that sufficient to burst the pipe. The same is true of any other size pipe. In fact, the size of the pipe has nothing whatever to do with the pressure the water may be under, but only with the quantity which may be passed through in a given time without excessive friction.

A one-inch pipe will carry a certain number of gallons of water per minute without undue friction, whether the pressure be ten or a hundred pounds per square inch. When the point is reached at which the friction becomes excessive the normal capacity of the pipe may be said to have been reached. More water may be forced through, but it will be at the expense of great waste in power. It costs money to force a water pipe above its capacity, and the higher the excess in capacity, the greater the relative cost in overcoming the resistance.

The practical way of avoiding this waste is to increase the diameter of the pipe until the desired added flow is had with only normal friction loss. We, therefore, deduce the rule, or fact, that the larger the flow the larger must be the diameter of the pipe; that it does not pay to force a pipe above its normal capacity, and that an increasing diameter decreases the friction or resistance offered to a given flow.

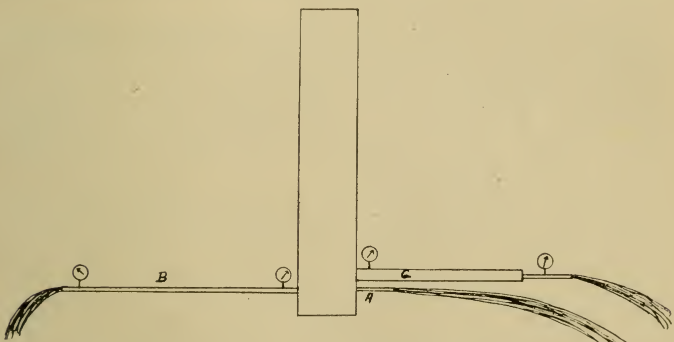


Fig. 4.

Another equation enters into the matter, however, viz: The length of the pipe. Inasmuch as friction comes mostly from the rough sides of the pipe, the longer the pipe the more friction there will be. In other words, friction is increased as diameter is reduced, or as length is increased. It decreases as diameter is increased or length decreased. Undue friction caused by long pipe also operates to consume power.

In Fig. 4 we see a water tank with pipes A, B, and C. It will be seen that from short pipe A the water spurts out with much force, also from long pipe C, though not quite so strongly. But from long pipe B it comes more slowly with less force.

On pipes B and C we see two gauges. The one nearest the tank, pipe B, is found to register practically full pressure, say 50 pounds, the same as though attached directly to the tank. The other, however, registers much less, say 30 pounds. Both are attached to the same pipe. No valve is between them. Where has the pressure gone? The answer is: It has been consumed, or used up in forcing the water against the resistance of the long pipe.

Pipe C also has two gauges, but the pipe, for a portion of its length is of larger diameter. We find that under those conditions the water spurts out with greater force than from pipe B, and that the two gauges register more nearly together, showing much less loss of pressure between them. The reason is that we have eliminated much of the resistance by increasing the diameter of the pipe for a portion of its distance. I believe almost anyone can readily grasp the idea presented, but be sure you do grasp it, since it is one of much importance.

What has been said of the water pipe applies in practically the same way to wires carrying current. There is little or no difference except that, while the pressure on water may not exceed the bursting point of the pipe, current may be under any pressure it can be raised to, but if wires be forced too far above their capacity, as to amperage, they will heat and may finally burn off, thus stopping all flow.

A wire of any size will carry current at any voltage. The voltage has absolutely nothing whatever to do with the necessary size of the wire. You could carry current at 1,000,000 volts on a wire no larger than a silk thread. You could, however, only carry a very small quantity—amperage.

A wire of a given size will carry a certain, definite amount of current (amperage) without undue friction (resistance). Beyond that point the friction becomes excessive, manifesting itself in loss of pressure (voltage). The pressure is consumed in forcing the current against excessive resistance, precisely as in the case of the water pipe. This, of course, means loss of power—waste, which is registered on your meter. If an attempt be made to force through amperes largely in excess of the wire's normal capacity it, the wire, will, as has been said, get warm, hot, red hot or white hot, according to the amount of excess, and may finally burn off entirely if the overload be carried far enough.

Precisely as was the case with the water pipe, the resistance of a wire to a given current flow decreases as the diameter is increased, or as the wire is made shorter. Conversely it increases as the diameter is made smaller or as the wire is made longer.

If a wire be long, though only carrying its normal capacity, there will be a "drop" in voltage at its end. The pressure will act just as does the pressure in water pipe B, Fig. 4, though possibly not to such excessive degree. If the diameter of the wire be increased, the same as is pipe C, Fig. 4, the electrical result will be the same as in the case of the water. The pressure at the end of the line will be largely restored. You could also restore pressure at the end of the line by reducing its length, always assuming it to not be loaded above normal capacity.

Resistance increases.........	With increased length of wire or As diameter is decreased
Resistance decreases........	As length of wire is decreased or As diameter is increased.

Different metals offer varying resistance to electric current. Also various alloys of metals offer varying resistance. Taking the conductivity of pure silver, which is practically the same as that of pure copper, at 100%, we find the metals to have the following relative conductivity:

Silver, 100%.	Copper, 100%.
Gold, 75%.	Aluminum, 55%.
Zinc, 28%.	Platinum, 17%.
Wrought Iron, 16%.	Nickel, 12%.
Tin, 12%.	Lead, 8%.
Cast Iron, 3%.	Mercury, 1.6%.

German silver, composed of copper 5½, zinc 2 and nickel 3½ parts, 3.5%. German silver, composed of copper 5, zinc 3½ and nickel, 1½ parts, 7.5%.

The above is, aside from the German silver alloys, based on pure metals of the various kinds.

Copper is the one metal combining, in high degree, the excellent electrical conductivity, relative commercial cheapness, ductility, and tensile strength necessary for electrical conductors. It has, therefore, become the universal metal for electric wires.

In this connection let it be noted that the resistance of copper rises as its temperature rises. In other words, its capacity as a conductor decreases as its temperature increases. On the other hand, the resistance of carbon becomes less as its temperature is increased. For instance: The resistance of the filament of an incandescent lamp of the ordinary type is about twice as much when cold as it is when the lamp is at candle power. Its resistance is, therefore, calculated on that basis. Also, as a rule, the resistance of liquids, and of insulating materials, becomes less as the temperature rises. In general, however, the resistance of all metals rises with the temperature; that of copper increasing about four-tenths of one per cent. for each increase of 1 4/5 degrees Fahrenheit.

Round wires are measured as to their cross-section, or area, in circular mills. One one-thousandth of an inch is called a "Mill." A circle one one-thousandth of an inch in diameter is called a *"circular mill."* A round wire 1/1,000 of an inch in diameter is said to have a cross-section, or area, of one mill. This is the unit used in measuring the area or cross-section of all round wires. Now—follow me closely.

The areas of all circles are proportional to the squares of their diameters.

It then follows that if the area of a wire one mill in diameter is called one mill, or one circular mill, wires of other sizes will have an area, or cross-section, numerically equal, in circular mills, to the square of their diameters.

A wire ¼ inch in diameter would be (1,000 divided by 4) 250 mills in diameter. Its area, or cross-section, would then be equal to the square of its diameter (square of the diameter means the diameter multiplied by itself) $250 \times 250 = 62{,}500$ circular mills. The area in circular mills of any wire can be found by measuring its diameter in thousandths of an inch and multiplying the measurement by itself. The table on page 34 will serve most purposes, however.

It is well to know how to figure the resistance of a wire of any size or length. The process is simple, provided the standard be known. The accepted standard is the resistance of a wire one circular mill in cross-section and one foot in length, made of the same material as the wire to be measured. This is known as the "Mill Foot." The resistance of such a wire, made of ordinary commercial copper, is given at 10.5 ohms. That is to say, a wire made of ordinary commercial copper, such as wires are made of, one foot in length and one mill in cross-section, offers 10.5 ohms resistance. Now, if you had a wire say 400 feet in length and one mill in cross-section, it is evident that if one foot has a resistance of 10.5 ohms, then 400 feet would have a resistance of 400 times 10.5, or 4,200 ohms. If, however, the wire be 400 feet in length and 250 mills in diameter ($250 \times 250 = 62{,}500$ in cross-section), the resistance would then be equal to the resistance of 400 feet of the one mill wire divided by 62,500, since there would be, in effect, 62,500 wires, each one mill in diameter. Hence we get the rule:

To find the resistance of a copper wire multiply its length in feet by 10.5 *and divide that product by its cross-section in circular mills.*

For example: What is the resistance of a circuit 300 feet in length, size of wires No. 8?

There being two wires in a circuit we would have 600 feet of No. 8 wire. Looking in the table I, (page 32), we find that No. 8 wire has a cross-section of 16,384 c.m. We then have the problem: $(600 \times 10.5) \div 16{,}384$, which equals a trifle more than .38 of an ohm; for practical purposes say .4 of an ohm.

This rule is, of course, based on wire at a given temperature, and as the temperature rises the resistance will also rise, but there is only a very slight difference until it reaches a degree of heat sufficient to be sensible to the feeling. Beyond that the resistance rises rapidly with temperature.

The rule holds good for any amount of amperage up to the point of overload, and consequent rapid rise in temperature. For instance: If you proposed to only carry five amperes on a No. 8 wire, you would have the same total resistance that you would have if you pulled twenty. Theoretically, this is not strictly true, since there is rise in temperature from any increase in flow of current, but it is practically true for the reason that the rise, up to point of overload, is not sufficient to have any practical effect in increased resistance.

While it is not at all likely the operator will be called upon to figure such matters, still, for the sake of completeness I will tell you how to figure the size wire necessary to carry a given current with a given drop in voltage. Multiply the number of amperes by the length of wire in the circuit, and multiply that by the mill foot constant of resistance, 10.5, and divide by the number of circular mills in the wire. Result is number of volts loss.

Example: How many volts drop in a circuit of No. 8 wire, 100 feet long, carrying 30 amperes? No. 8 wire has a cross-section of 16,384 c.m. In the two legs of the circuit there would be $100 \times 2 = 200$ feet of wire, hence we would have:

$$\frac{200 \times 30 \times 10.5}{16{,}384} = 3.9 \text{ volts drop.}$$

The usual method is, however, not to figure actual volts drop, but to figure the size wire necessary to convey a certain current a certain distance with a given percentage of drop. It is done as follows:

$$\frac{\text{Amperes} \times \text{Length of wire} \times 10.5}{\text{Volts Drop}} = \text{Circular mills.}$$

For example: Suppose we wish to convey 20 amperes a distance of 300 feet with a loss in voltage not exceeding three per cent., voltage 110. What size wire is necessary? Three per cent. of 110 is $(110 \times .03)$ 3.3 There is 600 feet of wire in a 300-foot circuit. We then have:

$$\frac{20 \times 600 \times 10.5}{3.3} = 38{,}182,$$

which is the number of circular mills the wire must contain in cross-section. Looking in the table (page 32), we find that a No. 5 wire has 33.124 and a No. 4 has 41.616 c.m. area. We must therefore have a little more than 3 per cent. drop, using a No. 5, or else use a No. 4.

In my opinion these rules are very conservative. I find they figure out in such a way that the Underwriters' table of allowance (page 32) gives approximately a 3 per cent. drop for rubber covered on 100 foot circuits. On the weatherproof the drop would be very much greater; therefore, I assume that the rules are even more than safe. However, they are the rules ordinarily used by electricians for figuring wire capacity.

As has already been said, the two wires of a circuit, being of opposite polarity, have an affinity for each other which is represented in the voltage. There is a constant effort of the current to get from one wire to the other, and it is prevented from so doing by insulation.

Insulation.—Not only must the wires be insulated from each other, but also from the ground, since it is a conductor, and if one of the wires be grounded (an electrical connection between the wire and the ground is called a "ground") at one point, and the other wire be grounded at some point, perhaps a few inches or a mile or more away, the current will go through the earth from one ground to the other. If such a ground exists on your house lines at any point on the house side of the meter, it will allow current to escape, which loss will register on your meter, thus adding to your current bills.

Insulation consists in isolating the wires by means of some substance which is a non-conductor. Certain substances, such as rubber, glass, porcelain and mixtures of various kinds are called non-conductors, because they have such extremely high resistance that ordinary voltage will not force current through them. We, therefore, cover them with rubber or some equally effective insulating material and suspend the wires on porcelain or glass insulators. What is termed "rubber cover" insulation is a coating of rubber on the wire itself, over which is a canvas cover impregnated with an insulating mixture. Such insulation has high resistance, and wire thus coated may safely be placed inside metal pipes called "conduit."

Modern operating room practice is to place all circuits inside metal conduit, the two wires of a circuit being placed side by side in one pipe. No more than the two wires of a circuit may be placed in one pipe, however, except that in the case of a three-wire circuit, all three wires may occupy one conduit. The metal conduit protects the wires from any possibility of damage to the insulation, and in case of heating from overload there can be but slight danger of setting fire to anything.

In case conduit is not used, then the wires should be thoroughly insulated upon porcelain or other equally effective insulators. All wires should be stretched tight and put up in neat, workmanlike manner, so as to be both mechanically and electrically perfect. Loose wires, or wires run hap-hazard, tell of a poor workman. They are a standing advertisement of the slovenliness of the man who put them up. However, as this subject has been treated more fully under the heading "Operating Room," we will pass it by.

Should you at any time have occasion to run wires not protected by conduit through a wall, it is necessary that the wires be insulated by porcelain tubing extending clear through. Hard rubber tubing is no longer allowable for this purpose. The porcelain tubing must be firmly fixed in the hole so that it cannot slip out of place. You can easily drill a hole in a brick wall by filing notches similar to saw teeth on one end of a piece of water or gas pipe and using it as a drill, turning it constantly as you wield the hammer. If conduit is not used, keep all circuit wires at least 2½ inches apart.

In attaching wires to insulators, raw wire must not be used for tie wires. The tie wires must be covered with insulation the same as that of the circuit wires they are attached to. If you put up porcelain insulators with nails, first drive the nail through a bit of leather. This forms a cushion so that you can drive the nail down tight on the insulator without breaking it.

Wire Splices are something every operator should know how to make, and make right. An imperfect splice will heat and cause loss of energy. It may cause the wire to burn off entirely. In any event it is a constant source of loss of energy through its excessive resistance. A splice must be electrically perfect, and should in all cases, unless a strictly temporary joint, be soldered.

In Fig. 5 the correct method of making wire splices is illustrated. First, the insulation must be removed from the two ends to be joined, for a distance of from two to four inches, according to size of the wire. The insulation may be cut away with a sharp knife, but there is a right and wrong way to do it, as there is to do everything. The insulation should be whittled away just as you whittle a lead pencil. Never cut the insulation square off by running the knife blade around the wire. This makes a very neat looking job, but the trouble is that the blade is likely to cut a slight ring around the wire, and this ring acts

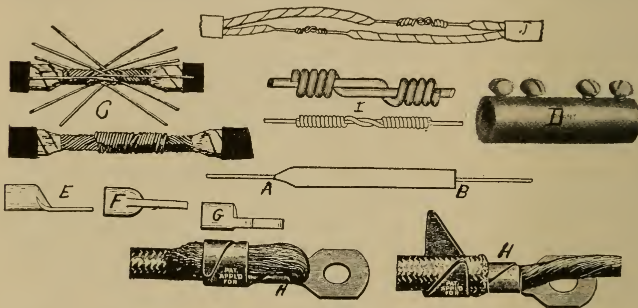


Fig. 5.

very much as a scratch on the surface of glass does, causing the wire to break very easily at that point. The correct method is shown at A, Fig. 5, and the incorrect at B. What is perhaps the best method of making a splice in asbestos covered, stranded wire is illustrated at C, Fig. 5, except that the strands should be divided into about six sections.

After removing the insulation the wire ends must be thoroughly cleaned, until they shine. This may be done with emery paper, or by scraping with a knife blade. But, however it is done, the wire must be made perfectly clean, else there will not be good electrical contact. The wire ends must then be twisted tightly together as at I, Fig. 5, after which the joint must be soldered. Underwriters' rules provide that a wire splice must be made both mechanically and electrically perfect before soldering. After the joint is made, as per Fig. 5, proceed to solder it as follows: Wet it thoroughly with a soldering fluid, or its equivalent, which may be had from electrical dealers in stick form. An excellent soldering fluid is made of

Saturated solution of zinc chloride	5 parts.
Alcohol	4 parts.
Glycerine	1 part.

After thoroughly wetting the joint with the fluid, or rubbing on plenty of the flux in stick form, hold the wire in the blaze of a gasoline torch until warm, and then also hold in the blaze a piece of solder, which may be had of electrical dealers in wire form, until it melts and runs all through the joint. Care must be had not to get the wire too hot since, especially with the smaller wires, too much heat injures the wire and reduces its carrying capacity; also if too hot the solder will run through and out of the joint. If the soldering is properly done the joint will have more mechanical strength and as great carrying capacity as the wire itself. *All joints must be soldered,* except they be strictly temporary, say to use for one day only. After soldering, the splice must be wrapped with insulating tape, to the depth of the original insulation. One or two thicknesses of tape is not enough. If properly done, the use of a wire connector, D, Fig. 5, is permissible; but the soldered joint is best. Wire connectors must not be used for joining asbestos covered, stranded wires, except the end of the wire be first run full of solder, thus binding the strands together in a solid mass.

For wires connecting to switch binding posts, or other binding posts, lugs similar to E, F, G, Fig. 5, must be used, but before inserting wire ends into connectors, or lugs, they must be thoroughly cleaned by scraping with a knife blade, or polishing with emery paper. Where such lugs are used, the wire must be soldered into them. This is best done by heating the lug as directed for making splices, and melting solder into it until it is about a quarter full. Then shove the wire carefully in as far as it will go, being careful to first cover it with soldering flux. Shove it in carefully or the hot solder will spurt out and burn you.

For asbestos covered, stranded wire, where it connects to the lamp, a lug similar to H-H, Fig. 5, is used. Solder cannot be used inside the lamphouse, of course, since it would melt, so these copper lugs are employed. Clean out the inside of the lug thoroughly, until it shines; also clean the wire strands carefully, if you want good electrical contact. Keep always in mind the fact that unless a wire splice or joint be very carefully made it will heat more or less and cause resistance, which means constant loss, as long as the splice or joint is used. The loss from one imperfect splice, or joint, may be slight, but the combined loss from several may amount to considerable.

As has been said, copper wires of various sizes will carry a certain limited number of amperes of current without heating or excessive loss through resistance. The National Board of Fire Underwriters have, by careful test and experiment, determined and fixed the amount any given size of wire may be allowed to carry. This is set forth in the Table I. We begin with No. 16, since that is the smallest wire the rules of the Underwriters allow to be used inside a building, except in fixtures. There are two kinds of insulation, viz: "Rubber covered" and "weatherproof." Wire covered with weatherproof insulation is allowed to carry considerably higher amperage for a given size than is rubber covered, but it must not be used inside a building, or anywhere else except in places where it will be surrounded by free air. For convenience I also, in this table, give the area and diameter of the various wires in circular mills. B. & S. means Brown & Sharp gauge, which is the standard in this country. It is well that the operator own a B. & S. wire gauge (see Fig. 6). In fact, he should by all means have one, though they are rather expensive.

TABLE I—WIRE CAPACITIES

B & S.	Amp. R. C.	Amp. Weatherproof.	C. M. Area.	Diameter in C. M.
16	6	8	2,601	51
14	12	16	4,096	64
12	17	23	6,561	81
10	24	32	10,404	102
8	33	46	16,384	128
6	46	65	26,244	162
5	54	77	33,124	182
4	65	92	41,616	204
3	76	110	52,441	229
2	90	131	66,564	257
1	107	156	83,521	289
0	127	185	105,625	325
00	150	220	133,225	365
000	177	262	167,100	410

The above table is official and in no case must the capacities indicated be exceeded. There is more than one reason why this table should be strictly adhered to. In the first place, if you attempt to overload your wires, or any one of them, and it be found out, you automatically void any insurance you may have. In the second place you run more or less danger of fire, according to the amount of overload, through the wires becoming overheated. In the third place the loss through resistance will be excessive and that loss will register on your meter, besides affecting the brilliancy of your lights. Therefore you see the overloading of wires is a costly thing to do, even though you get into no other trouble through exceeding the figures given in the table.

In this connection it is desirable to know the amount of current consumed by incandescent lamps of various candle power. Hence:

TABLE II.—LAMP CONSUMPTION

110 Volts			220 Volts		
C. P.	Watts.	Amperes.	C. P.	Watts.	Amperes.
4	18	.16	..	...	...
6	24	.22	8	36	.16
8	30	.27	16	64	.29
16	56	.51	32	122	.55
32	112	1.00	50	190	.86
50	175	1.60	..	...	...

By use of the Tables I and II you are enabled to ascertain the size of wire necessary for any number of incandescent lamps. Suppose, for instance, you desire to operate a cluster of ten 32 c.p. incandescent lights, and a motor taking three amperes, from one circuit; voltage 110. Looking at the lamp consumption table, you see that each 32 c.p., 110 volt lamp requires one ampere of current. Ten lamps would then consume ten amperes, and the motor would bring the total up to 13. Looking in Table I we see that No. 14 wire is only rated at 12 amperes, whereas No. 12 will carry 17. However, 13 amperes would overload the smaller wire, therefore we must use No. 12. If, however, the circuit be out of doors and the wire not near any woodwork, but suspended on poles, then we could use weatherproof, and the No. 14 would be ample in size.

We learn also from the lamp consumption table that, while the amperage consumed by 220 volt lamps is less per c.p., the energy (wattage) used is considerably greater. Hence it is comparatively expensive to use high voltage incandescent light. By the combined use of these two tables it is possible to figure out any problem of wire capacity in which incandescent lights alone are concerned.

Wires May Be Measured by using a Brown & Sharp (B. & S.) wire gauge, Fig. 6. In using this gauge, one of which every operator ought to own, it is the slot, not the hole, which forms the gauge. Select the slot which most nearly fits the wire, and the number of the wire, B. & S. gauge, will be found opposite. If the gauge is a good one, you will find on its opposite side the diameter of each slot in thousandths of an inch, as per table. You may also ascertain the gauge of a wire by measuring its diameter with a machinist's micrometer calliper, in thousandths of an inch. You can then look in the table and, under head "C. M. Diameters," find the corresponding diameter. You may also square the diameter (multiply it by itself), which gives the area in c.m. Look in "C. M. Area" column, Table I, and select the corresponding size. Either method is reliable.

Fig. 6.

Asbestos Covered Stranded Wire May Be Measured by the simple process of measuring the diameter of one strand, in thousandths of an inch, square that measurement (multiply it by itself), and multiply the result by the number of strands in the wire and you have its total area. Table I will then supply the area of a corresponding solid wire. However, for the use of operators, all of whom use stranded wire, I give table of diameters and area of wires usually used in asbestos covered stranded wire.

TABLE III.

B. &. S. Gauge.	Diameter in mills.	Area in Circular Mills.
25	17.9	320.4
26	15.9	252.8
27	14.2	201.6
28	12.6	158.8
29	11.3	127.7
30	10.	100.
31	8.9	79.2
32	8.	64.
33	7.1	50.4

I have before me, as I write, a stranded asbestos covered wire. Measurements show the strands to be 10/1,000 of an inch in diameter, or, what amounts to the same thing, 10 mills in diameter. Reference to Table III shows a wire 10 mills in diameter to be No. 30 B. & S. gauge. Actual count shows 250 of these strands in the wire. Reference to Table III shows No. 30 wire to contain 100 c.m. (multiplying the diameter by itself gives the area). Now, if we multiply the area in c.m. of one strand by the number of strands we shall have the total area of the wire. $100 \times 250 = 25{,}000$ c.m., the entire area of the wire. Referring to Table I, we see that No. 6 wire contains 26,244 c.m. area. Therefore we conclude the wire under investigation is not a No. 6, or, rather, it is a dishonest wire, since it is 4,264 c.m. in excess of a No. 7 and lacks 1,244 c,m, of equaling a No. 6, for which it is intended and sold. To be a No. 6 it must have 12 more strands.

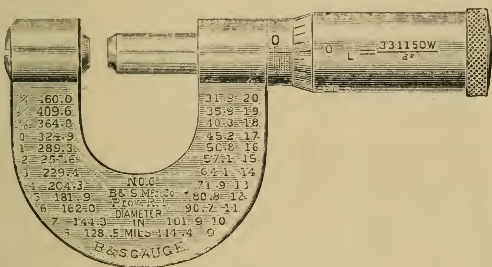


Fig. 7.

By the intelligent use of this table operators will be enabled to check up their stranded wire and make complaints on any not up to No. 6 requirements. Enough of these complaints will eventually force manufacturers to stop stealing (that's what it amounts to) copper. The asbestos wire, being subjected to high temperature at one end, and some heat, usually, at the other, is the weakest point in your circuit. It should, therefore, be fully up to underwriters' requirements in area.

A wire gauge is not very reliable, except in the hands of an experienced wireman, for measuring such small wires. It is better to have a machinist measure one of the strands for you, with his micrometer calliper. Have measurements made of three or four strands from different parts of the wire. The Brown & Sharpe Company, Providence, R. I., put out a micrometer calliper, Fig. 7, which gives, on one side, equivalent wire sizes, thus:

57.1 = No. 15, meaning that 57.1 thousandths of an inch in diameter is a No. 15 wire.

We have already learned how to figure the resistance of wires of any size and any length, also how to figure voltage drop on any circuit. There is, however, still another, and more convenient way to get at such things.

TABLE IV.

—Column A—			—Column B—		
110 Volts.	220 Volts.	B. & S. Gauge.	110 Volts.	220 Volts.	B. & S. Gauge.
627	1,254	14	836	1,672	14
787	1,578	13	1,052	2,104	13
999	1,998	12	1,332	2,664	12
1,260	2,520	11	1,680	3,360	11
1,587	3,174	10	2,116	4,232	10
1,995	3,990	9	2,660	5,320	9
2,523	5,046	8	3,364	6,728	8
3,180	6,360	7	4,240	8,480	7
4,014	8,028	6	5,352	10,704	6
5,061	10,122	5	6,748	13,496	5
6,372	12,744	4	8,496	16,992	4

Table IV is used as follows: Column A is arranged for 3% voltage drop and Column B for 4%. Multiply the length of one wire of the circuit, in feet, by the number of amperes it is to carry. Then, according to whether you propose to have a 3% or 4% drop, look in Column A or B, and, under voltage you are using, find number most nearly corresponding to the product. Opposite, under B. & S. Gauge column, will be found the wire size necessary. For example, suppose you propose running a circuit 100 feet in length — from starting point to end, I mean, not both wires—to carry 45 amperes; voltage 110. Multiply 100 by 45, which gives 4,500. Suppose we are satisfied with a 4% drop. Looking in the 110 voltage column of column B, we find that 4,240 and 5,352 are closest, one indicating a No. 8 and one a No. 6 wire. The No. 7 will give a little more than 4% drop and the wire half-way between a No. 5 and No. 6. The 220 column should be used when figuring three-wire circuits, carrying 110 on a side. The size found by the tables will be correct for all three wires. For alternating currents, single-phase, multiply amperes by feet, as directed, and then multiply that product by 1.1 before proceeding to consult the tables. For three-phase, three-wire systems, instead of multiplying by 1.1, divide by 2.

It must be borne in mind that an incandescent lamp has a fixed resistance, which allows a certain definite amount of current to flow under a certain, fixed voltage, say 110. It requires exactly that voltage to force the necessary current through the filament resistance to bring the lamp up to candle power. It therefore, follows that if there be much voltage drop, through excessive line resistance, or any other cause, the lamps will not burn up to candle power. Hence, the resistance of long circuits must be carefully figured. For short circuits Table No. I answers every purpose.

WIRE SYSTEMS

The operator should have a good general knowledge of the various wire systems with which he is likely to come in contact. This is absolutely essential should he take a position with a traveling show. It is not my intention to go deeply into the matter, but merely to set forth such things as seem necessary to enable the operator to connect his lamp to any of the various systems without danger or trouble.

There is one system to which a projection arc lamp cannot possibly be connected, or rather on which such a lamp cannot be operated. This system is known as the "Series Arc" system, and is used only for street arc lighting. Instead of the two or three wires common to other systems the series arc system has but one. Each lamp carries all the amperage of the system, or circuit, and for each lamp there is an added pressure of about fifty volts, thus: A circuit of ten lamps would have a pressure of about (50×10) 500 volts. If another lamp be added, the voltage would have to be raised to 550; and so on. Do not attempt to connect such a system or you will merely succeed in getting into serious trouble. It is not practical, for more reasons than one.

There are also two systems which were, at one time, in use, called respectively the Series-Multiple and the Multiple-Series. These systems need not be dealt with, however, as they have practically been abandoned.

The Multiple Arc, also called the Parallel, also called the Two-Wire System, is, in effect, what the operator encounters; the Three-Wire System being but a variation of the same, so far as electrical effect goes.

In Fig. 8 we see a multiple arc, parallel, or two-wire system. The electrical action is as follows: The heavy lines represent the street mains, the light ones, house feeders. The current flows out from the dynamo, over the positive wire, escapes through the various lamps and motors to the negative wire and via it travels back to the generator.

In one of the houses, represented in sketch, we see a projection lamp connected. You may connect to this kind of a system at any point provided (a) the wires, transformer (if any), and switches be large enough to carry the current for your lamp, plus whatever else it may have to carry. (b) That the fuses

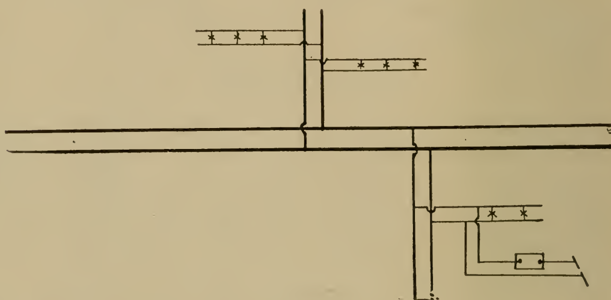


Fig. 8.

be large enough to carry the current for our lamp plus whatever else they have to carry. (c) That the meter (if there is one) be large enough to carry the current, for our lamp, plus whatever else it may have to carry. We must, however, supply resistance according to the voltage.

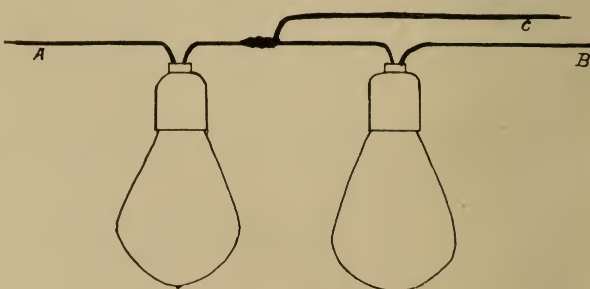


Fig. 9.

Voltage May Be Tested in a number of ways. A voltmeter is best, of course, but such an instrument is seldom available.

You may examine the paper label on one of the incandescent lamps, consulting Table II, page 33, if only wattage is given. You may connect two 110 volt incandescent lamps in series, as per Fig. 9. Touch the ends of the wires A—B to the circuit wires, one end to each wire. If the lamps burn up to candle power it is approximately 220 volts pressure. If, on the other hand, the lamp carbons only burn red, touch wires A—C, instead of wires A—B to the circuit wires, and if lamp X burns to c.p. the current is 110 volts. If it burns above c.p. the voltage is probably 120 or 125, and if below c.p. it is probably 104. You may also tell by examining the plate on the meter, if there is one. The practiced man can judge voltage very closely by the lamp test, and even the novice can make no serious error if he follows the above carefully.

Whether the Current Is D. C. or A. C. may be determined by (a) Looking for a transformer (page 142) outside the building. If there is one, the current is alternating, but its absence does not offer conclusive proof that it is not A. C. (b) By looking at the meter plate, if there is a meter. (c) By slightly moistening the fingers and touching two wires of opposite polarity, thus taking a slight shock. If it is A. C. the current will feel "jerky." This latter test is not recommended to the novice. Of course, if there is a telephone handy, you may call up the power house and ask what the current is. This, however, is not always convenient. As has been said, you may connect to the wires, observing the precautions named, at any point you wish. Your best point, however, is at a panel board if there be one. Frequently in giving shows in school houses and churches the writer has found the wires entering the building to be too small, and has been obliged to carry his own wires out of a window, or other convenient opening, attaching same directly to the street mains, supporting them as best he could between there and the building.

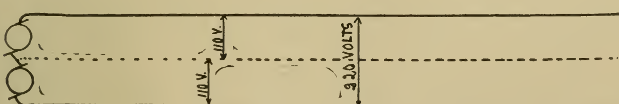


Fig. 10.

The Three-Wire System is somewhat more complicated, though very simple, once it is understood. It is, in effect, the combination of the output (amperage) and voltage of two generators, either one of which may be used singly, or both together, according to how connections are made. When two dynamos are connected in series, Fig. 10, the voltage of one machine is added to that of the other. If they are 110 volt dynamos the total pressure between the two outside wires will be 220 volts. If the dynamos be 220 volt machines, the line pressure would be 440, etc.

If we now add a third line, connected as per dotted line, we have what is termed a "Three-Wire" system, and by connecting lamps between the center (called the "Neutral Wire") and the lower wire, we would only be using the one generator, and would only get its pressure, usually 110 volts. If we made the connec-

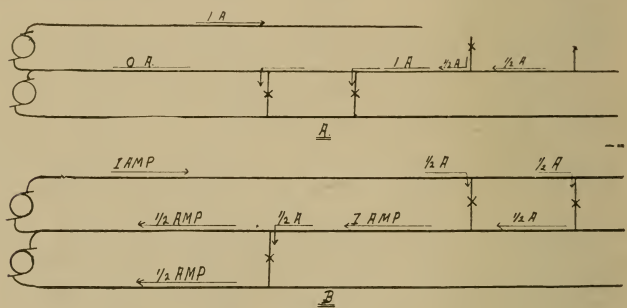


Fig. 11.

tion between the neutral and the upper wire, we would be pulling from the upper dynamo only, and would get only its voltage (both dynamos must be of the same voltage). If we connect between the two outside wires we would then be pulling from both dynamos and would have double the pressure (voltage) of either one.

In practice, however, this must be modified, thus: The aim and intent is to make both dynamos perform an equal amount of work. This is called "balancing the load." To accomplish this it is necessary to make connections so that the lamps and motors attached between the neutral and one outside wire, and the neutral and the other outside wire, will use an approximately equal number of amperes. The actual effect of the three-wire system is to burn the lamps, etc., in series on 220. This is illustrated in A and B, Fig. 11.

In A, Fig. 11, we have a representation of the three-wire system, for convenience only showing the three wires leading out from the generators, without any branch lines. Between the neutral and each outside wire is installed two 16 c.p. 110 volt lamps, the generators being 110 volt machines. The electrical action is as shown by the arrows. One ampere of current at 220 volts pressure flows out from the dynamos via the outside positive wire, which we shall call the top wire in the sketch, and continues to the first lamp, where one-half of the ampere passes through its filament and starts back on the neutral wire. The other half ampere continues along the upper wire to the second lamp, through which it passes and starts back on the neutral wire, again combining with the first half ampere, so that the neutral wire is now carrying one ampere (it is a little more than an ampere since a 16 c.p. 110 volt lamp takes .51 of an ampere). One-half the 220 volts pressure has been consumed in forcing the current through the lamps and it is now on the neutral at 110 volts. It travels back toward the dynamos on the neutral until the first lamp on the other "side" is reached, when one-half an ampere passes through it to the lower outside conductor and starts back to the dynamo on that wire. The other half ampere continues on the neutral until the second lamp is reached, through which it passes, combines with the first half ampere and travels back to the generators on the lower outside wire. The two sides being in perfect "balance," that is to say, having lamps consuming the same total amount of current, the neutral wire could be cut off entirely between the two lower lamps and the dynamo without in the least affecting the lamps. Between the lower lamp, nearest the dynamo, and the dynamo itself, there is no current at all flowing in the neutral. In the foregoing I seek to convey the idea, at expense of technical correctness. At B, Fig. 11, we see a three-wire system not perfectly balanced. There are two 16 c.p. lamps on one side and only one on the other. In consequence the neutral wire carries ½ ampere between the lower lamp and the dynamo. This means that the lower dynamo is only furnishing electric energy sufficient to burn one lamp, while the upper one is "pulling two." In other words, the upper dynamo is doing double the work performed by the lower one.

I have gone to some length in explaining this for the reason that it frequently is the case that the light companies will not allow a projection lamp to be hitched to the neutral and one outside wire, thus supplying 110 volts. Instead they insist on its being connected to the two outside wires, which puts it on 220 volts. This is by reason of the fact that the projection arc is not a steady load. It is frequently shut off. From the above you can, I believe, see the desirability, from the light company's point of view, of having the load constantly balanced, since it is then equally distributed between the two generators. This is particularly desirable if the dynamos are working up to, or nearly to, capacity. If the load otherwise is well balanced and a projection arc pulling, say 45 amperes is lighted, the same being hitched to the neutral and one outside wire, then one dynamo is compelled to carry that much more load than its mate. If the projection arc burns steadily all the time, then sufficient incandescent lamps could be switched to the opposite side to balance its amperage, and all would be well. This, however, is not the case and the only possible method of dividing the load of such

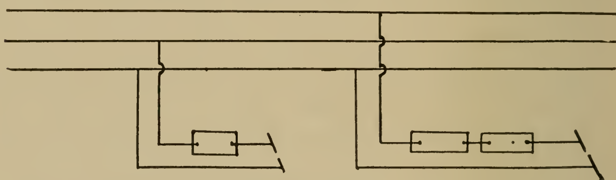


Fig. 12.

a lamp between both generators is to hitch it to the outside wires. If rheostatic resistance is used, it is very wasteful, as is explained under the head of "Resistance."

Aside from the matter of balancing the load, a projection arc lamp may be hitched to the neutral and one outside wire of a three-wire system at any point, provided the wires, fuses, switches, meter, and transformer (if there is one), be large enough to carry the load, plus whatever else they must carry. You will almost always find the three-wire systems to carry 220 volts between the two outside wires and 110 between the neutral and either outside wire. To all intents and purposes, except for the balancing the load feature, the neutral and outside wires are exactly the same as the multiple arc, or parallel system, before described. The electrical effect as between the two outside wires of the three-wire system and the multiple arc system is identical, except that the former supplies 220 volts pressure, whereas the latter usually supplies approximately 110 volts. In connecting to the two outside wires, you must therefore supply resistance for double the pressure required for the neutral and either outside wire. The three-wire system is used both for A. C. and D. C. Where a three-wire A. C. system is found you are pretty safe in assuming it to be three phase (page 11) current, though it may possibly be what is termed mono-cycle. This is, however, only of interest to the operator when motors are used. The mono-cycle system can only be used on induction motors. Only three-phase motors can be used on three-phase current. One thing I omitted to mention, viz: The center wire (neutral) of the three-wire system is both positive and negative. It is postive to one of the generators and negative to the other.

In Fig. 12 we see the method of connecting the projection arc lamp to a three-wire system, both on 110 and 220 volts.

You will observe that on 110 (outside and neutral) we use only one 110-volt rheostat. On 220 (two outside wires) we use either one 220-volt rheostat or two 110-volt rheostats in series, though two 110-volt rheostats in series on 110 volts will be somewhat overloaded. (See "Resistance," page 107.)

Switchboards and Fuses

SWITCHES

IT is essential that the operator understand the proper method of installing switches, and what switches are permissible for different classes of work; particularly as applies to knife switches. Of the button "snap" switches, little or nothing need be said in this work. They are used exclusively on incandescent circuits, and are simple enough to be readily understood. It must not be supposed that any kind of switch may be installed, in any kind of way, or that switches need no care or attention. Switches to the value of thousands of dollars are ruined annually through lack of intelligent care, and through carelessness or ignorance in their handling. One rule applies to all switches, and it should not be disregarded, viz.:

Never open a switch slowly.

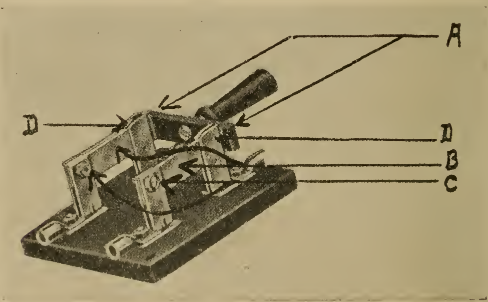


Fig. 13.

Switches should invariably be opened with a quick jerk. If it breaks a circuit carrying considerable amperage or high voltage, this becomes a matter of prime importance. If opened slowly there is likely to be more or less arcing between the knives of the switch and their contacts, which will burn and roughen the copper of both, thus perhaps making it difficult to again close the switch, and in any event causing it to make poor contact. Remember that a *quick jerk is the thing in opening a switch.*

In Fig. 13 we see an ordinary double-pole, single-throw knife switch, similar to those used in operating rooms. One of the very common faults found in switches is connection A, Fig. 13, where copper knife-bar is joined to insulating cross-bar working loose. These screws should be set up tight, and kept that way. If they are not, then switch bars B, Fig. 13, will be loose and wabbly, and may not strike contacts D-D squarely. This is likely to cause more or less sparking when the switch is closed, which roughens

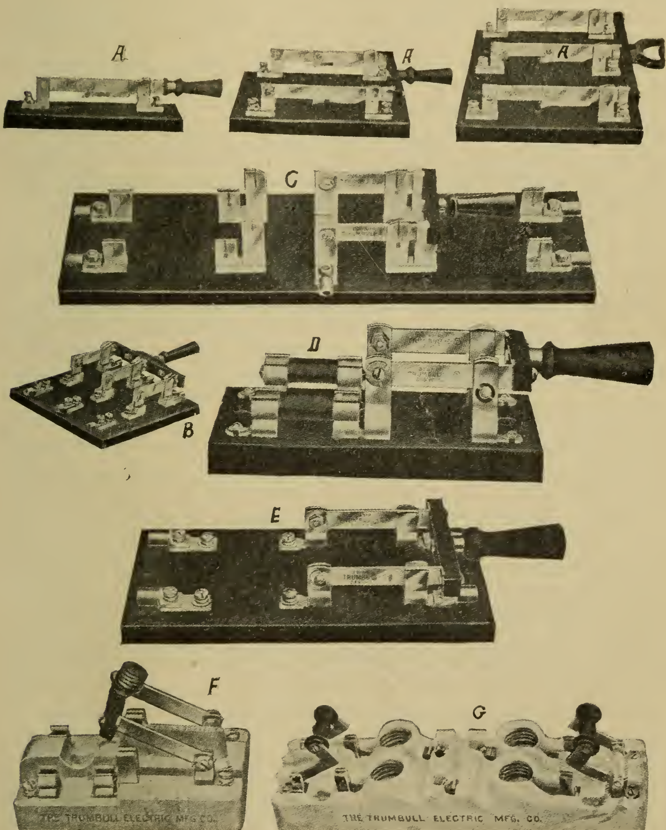


Fig. 14.

the ends of contacts D-D, as well as the bars, thus making matters still worse. Contacts C should be kept tight—as tight as possible without causing the switch to work too hard.

Knife switches come in a variety of forms, some of which are illustrated in Fig. 14.

A-A-A. Fig 14 are single-throw, single, double and triple-pole knife switches. B is a triple-pole single-throw knife switch made to carry link fuses. C is a double-throw, double-pole knife switch arranged to carry knife cartridge fuses at both ends. It is "double-throw" because the bars make a contact at either end—either way they are thrown. D is a single-throw, double-pole knife switch arranged to carry cartridge fuses. Switches may also be had to carry knife cartridge fuses. E is a single-throw, double-pole knife switch arranged to carry open link fuses. F and G are types of circuit switches used to control incandescent circuits. F carries cartridge fuses and G plug fuses. A switch is single, double or triple pole, according to whether it has one, two or three bars. Four pole switches are made, and even five and six pole, but they are seldom or never used in theaters.

Should you take charge of an operating room and find bars B, and contacts D, Fig. 13, roughened by arcing, they may be carefully smoothed up by using a very fine, very thin file, such as are used in making keys. You may also use a piece of 0 or 00 emery cloth or sandpaper, wrapped around a thin strip of metal. Screws of binding post contacts, to which wires attach, must be kept set up tight. One would suppose this would always be the case, but it is astonishing how careless some men are concerning such details. A loose, wabbly switch, with dirty, roughened contacts and loose binding post screws, tells of a careless, slovenly workman. Moreover such things mean waste of power, which counts up when the bill for current comes in.

It is an excellent plan to occasionally take the wires loose from their contacts and polish them, together with the contact surfaces of the binding posts with fine emery cloth, in order to insure the best possible electrical contact. I cannot impress upon you too strongly the fact that contacts should, even though they may *look* all right, be taken apart and thoroughly cleaned occasionally. Particularly is this true if the joint be subject to mechanical heat, as in the case of binding posts of rheostats, and those of the arc lamp. Copper oxidizes under the action of heat. If there is any heat at all (and where heavy amperage is employed there practiccally always is some, though it may be slight) a very thin, often invisible, scale forms on the wire under the clamp screw. This scale has high resistance, and that means loss. The loss in one connection may be very slight, but it is there nevertheless, unless electrical contact be perfect. Several such slightly faulty connections will, in the aggregate, amount to appreciable waste. Therefore keep all connections in perfect condition at all times. They should be as electrically perfect as the wire itself.

In Mounting Switches never put them up in such manner that the handle moves downward in closing the switch. Either have it swing sidewise or upward in closing. If it is otherwise there is a constant liability of the switch falling shut accidentally, should contacts C, Fig. 13, become a little loose, and this might be productive of some very unpleasant shocks, or even produce more serious results.

Double-throw switches must always be so mounted that the handle swings sidewise—never up and down.

Where practical, it is always advisable to connect the switches in such manner that the knives (blades) will be "dead" when the switch is open, but this ordinarily is not practical with double-throw switches, since the live wires are usually attached to the center contacts.

An Enclosed Switch is one having an individual covering, usually of sheet metal. This cover is to protect the operator from accidental contact with live parts of the switch, as well as to prevent accidental short circuits ("shorts"), by reason of something falling across the switch contacts or bars. With switches so protected it is of importance that the bars cannot in any way be brought into contact with the casing, or cover. I have seen such covers so made that, when the flap or cover is open, the handle of the switch could be pushed back far enough to rest on the metal of the casing. Now if the connections be so made that the bars are "alive" when the switch is open (a bad condition, but sometimes found), this would cause a dead short circuit, and blow the fuses; besides burning the bars and cover badly.

The Proper Location of Switches will be treated under other headings to some extent, but conditions are so diversified that no set rules can be given, except in a very general way. Convenience is ordinarily the main thing to be considered, except on the stage where all switches must be assembled at one point and adequately protected from accidental contact with scenery.

Uses of Types of Switches. The single-pole switch is seldom used in theaters, and its use, except for certain purposes, is forbidden by underwriters' rules. The double-throw, single-pole switch is of use in certain rheostat connections, as is explained under resistance. The double-pole, single-throw switch is the type used to control incandescent circuits, for operating switches and for all circuits except three-wire. The triple-pole, single-throw switch is used to control three-wire mains where they enter the main switchboard, and wherever else three-wire circuits may extend. The triple-pole, double-throw switch is of use in certain cases where it is desirable to make connection with two separate sources of electrical supply; also in certain rheostat connections. The double-pole, double-throw switch is of use in certain rheostat connections; also for connecting to two separate two-wire supply systems. It is also used for machine connections, but this latter is very bad practice.

Underwriters' rules require that switches have certain measurements, according to the voltage they are to be used on. Both the voltage and amperage capacity is stamped on some portion of all switches. Reject any switch not so stamped. A switch may be used on any voltage less than its stamping, or for any amperage less than its rated capacity, but it must not be used for voltage or amperage greater than its stamped rating. The higher the voltage the farther apart must be its knives and the longer they must be. 250 volt switches are the kind almost universally in use in theaters, though the current is usually 110 or 220; very seldom higher.

SWITCHBOARDS

It is essential that both the theater manager and the operator thoroughly understand the main switchboard. In some of the larger houses, where many circuits are used, the main switchboard is a large, imposing affair which looks very complicated. In fact, however, these boards are quite simple and easily understood, if one examines them closely and with intelligent scrutiny.

The following rules concerning switchboards are laid down by the National Board of Fire Underwriters, in their National Electrical Code, copy of which may be secured free by sending stamped, self-addressed envelope to nearest Underwriter's office and requesting same. These rules must be strictly observed in the installation of switchboards.

a. Must be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Switchboards must not be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board. The space back of the board must be kept clear of rubbish and not used for storage purposes.

b. Must be made of non-combustible material or of hardwood in skeleton form, filled to prevent absorption of moisture.

If wood is used all wires and all current carrying parts of the apparatus on the switchboard must be separated therefrom by non-combustible, non-absorptive, insulating material.

c. Must be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

If the wiring is on the back, there must be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall.

d. Must be kept free from moisture.

e. On switchboards the distances between bare live parts of opposite polarity must be made as great as practicable, and must not be less than those given for tablet-boards.

The location of the main house switchboard can only be determined by considering each individual case. What is best for one theater may not be at all suitable in another. Accessibility and convenience must be the main items for guidance. However, it may be said that the main board ought, where possible, to be so located that the man handling same will have a good view of the stage. This point is quite essential to the best handling of lights where vaudeville acts are used.

There are some houses where the main board is located in the operating room. I do not, however, consider this, except in occasional cases, as being the best practice. Emergency may arise in which it is imperative that the house lights be turned on instantly. This might be done by signal, but the bell might "go wrong" just at that time, or other things might happen to prevent the quick switching on of the lights by the operator or his helper. In strictly moving picture houses it is best to have the house lights handled both from the operating room and from below. This is not at all a bad plan even in combination houses. But the main board should in practically all cases be located below, rather than in the operating room.

Except there be strong reason against it, the current for every circuit in the house, including operating room and stage feeders, but excepting the exit and emergency lights (emergency lights are those ordinarily left burning all the time, such as foyer, hallway, and side lights), should be brought in through the main house switchboard.

On this board should be (a) the main fuses, located ahead (on the street side), of everything, except the exit and emergency lights and carrying the entire house load. (b) The main switch which kills everything except the exit and emergency lights. (c) Fuses for every individual circuit in the house, including operating room and stage feeders. (d) Service switches for each individual circuit, except the stage and operating room feeders. (e) A switch governing all auditorium circuits ordinarily extinguished during the performance, except when auditorium lights are handled from the stage.

Exit and Emergency Light Circuits must be tapped on the main house feeders, on the street side of the main house fuses.

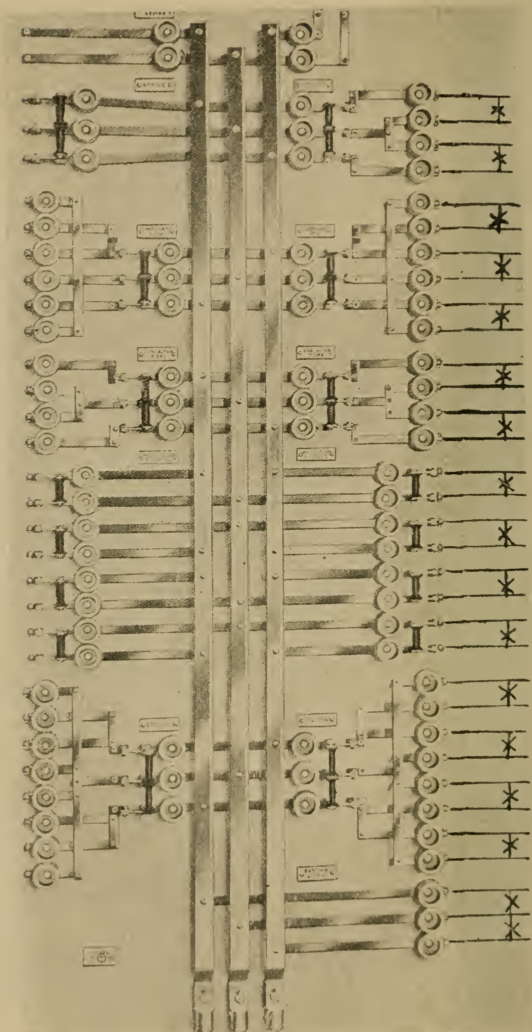


Fig. 15.

They should be protected by their own main fuses carrying all exit and emergency light circuits, and by individual fuses for each circuit. *They must be controlled by switches located in the box office, and by no other switches.* This is by reason of the fact that in case of fire, or other alarm, there is always the possibility of some excited employee pulling the wrong switch, or even the main house switch, thus plunging the entire theater in absolute darkness at the very time when the lights, particularly the exit lights, are most needed. One can never tell what an excited man will do. It has actually been known of an usher, on an alarm of fire being sounded, to rush to the switchboard and pull the main house switch. If the exit and emergency lights are located ahead of the main switch such a blunder would not extinguish them, at least, and the box office man or woman certainly would not pull their switch so that the house could not be plunged into total darkness. It is also possible that, in case of fire, a heavy short circuit would occur by something falling across the wires, thus possibly blowing the main house fuses.

Fuses controlling the operating room and stage feeders must be heavy enough to carry all current which can possibly be used at one time in the operating room or on the stage, with a safe margin above the actual possible consumption. It is well to fuse these feeders right up to their rated capacity, remembering that both operating room and stage have fuses of their own. Fuses used on switchboard must be of some approved enclosed type, either plug or cartridge, and an ample supply must be kept on hand, ready for instant installation in case one blows.

The switchboard should be enclosed in a substantial metal cabinet, provided with a substantial metal door with an easily manipulated latch and a lock. If the board be of considerable size one man should be placed in charge of it and no one else allowed to touch it. Too many men attending to the switchboard will be found a prolific source of trouble.

In the example presented in Fig. 15 I have purposely selected a somewhat complicated board. On one side I have indicated the circuits. If you will study the contacts you will readily trace out the connections. Taking the top switch we find the circuit starts off as a three-wire, through fuses, and a triple-pole switch, which latter controls the circuits. It then splits into two 2-wire circuits. The two central wires are connected, as we see, to the neutral, and the upper and lower to the outside wires of the three-wire circuit. Remembering that the neutral is positive to one outside wire and negative to the other, we instantly see that the two upper and the two lower wires are

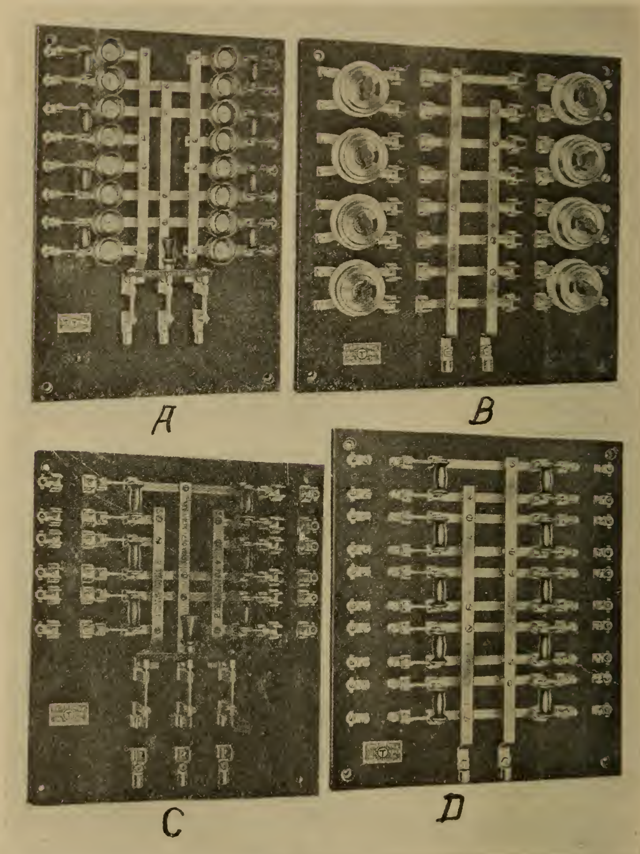


Fig. 16.

mates—that is to say, they are pairs forming two two-wire (multiple arc) circuits. We also see that we cannot extinguish one circuit without also extinguishing both, except we may remove the circuit fuses of one circuit.

Just below the center of the board is a bank of circuits tapped off as two-wire circuits right from the bus bars. By observing location of the screw heads we see which side the circuit is tapped on. We see there are four screw heads in each outside bus bar, in this bank of two-wire circuits, therefore there are four circuits on either side, and the circuit, provided each side carries the same c.p., is said to be "balanced." At the bottom we see a three-wire lead with fuses, but without switch. This is probably the stage or operating room lead, and should not have a switch on the main house board. The main switch and fuses controlling and protecting the entire board are not shown.

In Fig. 16 we see four types of what are commonly used as panel boards, but which may, with the exception of D, be utilized by small theaters as main house switchboards. A, C, and D are equipped with knife circuit switches, while B has those of the "snap" variety. A is equipped for plug fuses, B and C

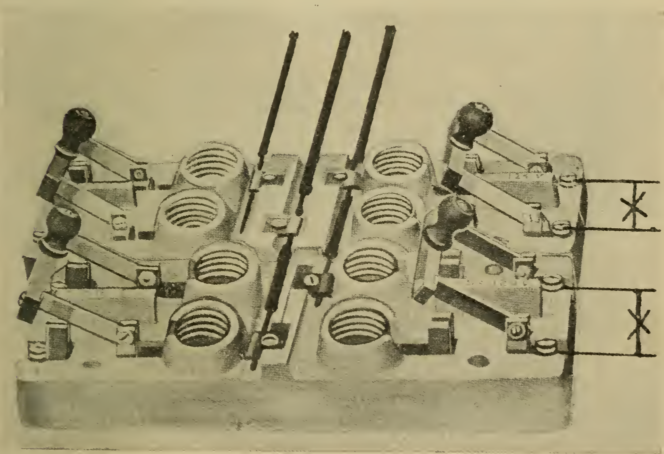


Fig. 17.

for cartridge fuses, and D for link fuses. Type D would not be available for a house board since it carries link fuses. Enclosed in a spring-door metal cabinet, however, it is ideal for the operating room projection circuits.

In the smaller houses of the store front type it is usual to build up the switchboard out of fuseblocks along the lines suggested in Fig. 17. Any number of blocks may be used if placed in a substantial metal cabinet, with door, back of same being lined with sheet asbestos not less than ¼ inch thick before installing the blocks. Such a board is acceptable, and really, aside from looks, is quite efficient. Blocks, called "panel cutouts," may also be had, which carry plug or cartridge fuses. Ahead of such a board should be a block carrying main fuses; also a main switch.

THE STAGE SWITCHBOARD

The Stage Switchboard should be located on the proscenium wall. It is the common practice to place it to the right of the stage, as one looks toward the audience. It should be protected by an iron railing, substantially constructed, not less than 48 inches high and located not less than 36 inches from the face of the board; same to be securely fastened to the floor in such manner as to withstand the shock of any person falling against it, or scenery striking it.

All fuses on stage switchboard must be approved cartridge or plug type. Open fuses must in no case, or under no circumstances, be used on a stage.

The stage switchboard should carry (a) main fuses carrying all stage circuits. (b) Service switches for each individual circuit, same plainly labeled with name of circuit it controls, thus: "Red Foots," "Blue Foots," "White Foots," "1st borders, white," "1st borders red," etcetera.

Stage switchboards need not be equipped with a cabinet and door, but every precaution must be observed to render accidental contact with scenery impossible. *Great care must be exercised* that all contacts be kept tight, and in perfect electrical condition, to prevent any possibility of heating. The wires should occasionally be examined to see that the insulation is in perfect condition. In fact, inasmuch as there is always more or less (usually more) inflammable material constantly exposed on a stage, it is impossible to be too careful with the electric installation and to maintain it in perfect condition. Underwriter's rules, quoted elsewhere, must be rigidly adhered to in installation of stage switchboards. Absolutely no one, except the man in charge of the stage switchboard should be allowed to touch it while a performance is under way, and the less people "monkeying" with it at other times, the better.

Stage switchboards should be wired from the back. This is not absolutely necessary, but it looks better and is better. This also is true of the main house board. It is not necessary that an expensive marble board be purchased. Fixtures like those illustrated in Figs. 17 and 18 may be had of any dealer in electrical goods.

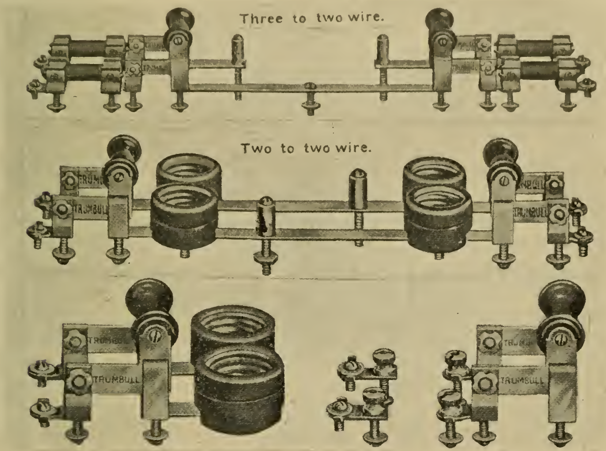


Fig. 18.

Purchase a marble or slate slab of your local marble dealer, first having ascertained length of fixture bolts, so that a slab of proper thickness may be selected. Any man of average intelligence can lay out, and drill the holes. Affixing the switches to the slab is then merely a matter of placing the bolts in the holes and tightening the screws. The sides must afterward be covered with a metal rim to receive the door, if it is to be a main house switchboard. If rightly done such a board will look five hundred per cent. better than those built of blocks, such as is shown in Fig. 17. Fixtures of this kind are surprisingly cheap and their installation, as has been said, is not at all difficult. First lay out the board on paper, just as you want it, locating all holes carefully. Then transfer the hole locations to the marble, or slate, and drill them. I am not sure, but I believe the manufacturers will supply you with plans giving drilling dimensions for all such fixtures.

FUSES

As we have seen, a wire is only capable of carrying a certain limited number of amperes of current with economy and safety. Overloading a wire causes excessive resistance, rapid deterioration in carrying capacity, and, if carried far enough, may cause the wire to become red hot, white hot, and finally burn in two. In the open air this might cause no other danger than the possibility of serious shock to some one from accidental contact with the broken wire though it would entail the inconvenience of having current cut off entirely until the burned wire could be re-joined. In buildings, however, the heated wire could, and very likely would, cause a fire, with large possibility of disastrous consequence.

A circuit is designed to carry a certain number of lamps, or motors, consuming a given number of amperes, not in excess of the rated capacity of the wire. As long as no more lamps or motors are installed on that circuit, and there is nothing wrong with the circuit itself, all will be well. There will be no possibility of trouble. But there is the ever present danger of something going wrong. Things may occur which will cause a sudden rush of current on the wires. A short circuit might occur. There might be a heavy "ground." A rise in voltage is possible. In either case the wires would, or might be, heavily overloaded. It is necessary, therefore, to provide some device which will automatically guard against these dangers. That device has been given us in the form of what is known as a "fuse."

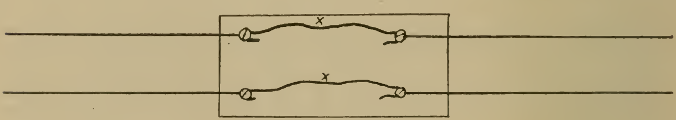


Fig. 19.

A fuse is nothing more or less than a short piece of metal, usually in form of a wire, made of a composition, or alloy which melts at low temperature. Copper will not melt until it has become white hot. This, as has been pointed out, will not do at all, owing to danger of setting fire to something. We, therefore, cut the circuit wires and join them with the short pieces of fuse wire X X, as shown in Fig. 19.

The wires X X are of a composition which will melt at very low temperature, as compared to copper—far too low to set fire to even the most inflammable material. It is true that very inflammable material has been set ablaze in the process of the blowing of a fuse. This, however, only occurs where the material is very close and very inflammable. It is not caused by the heated metal, but by the electric arc or spark forming at the instant of current stoppage. These short wires, known as "Fuse Wires," are supposed to be of a size to just barely carry the current normally being used on the circuit they protect without developing heat. If a circuit carries ten 16 c.p. incandescent lamps it would require practically 5 amperes of current and we would install fuse wires capable of carrying 5 amperes without heating. Five ampere fuses we would call them. If, for any reason, such as a short circuit or ground, or any amount of current in excess of the 5 amperes normally used by the lamps, began to flow, thus overloading the wires of the circuit, the wires and fuses would immediately begin to get warm, but this heating would only progress a very little way before the melting point of the fuse wires would be reached and passed. The fuse wires, or rather one of them, would melt, thus stopping all current flow until the damage be repaired by the installation of a new fuse. If a new one be put in before the cause of the heating is removed, the new fuse will at once melt, again stopping current flow. Thus you see the wires, lamps and motors (lamps and motors could also be injured through overload, as well as the wires), are protected in an absolutely automatic manner, provided always that the fusing be properly done. This, in brief, is the principle of the fuse, and how it operates.

Fuse Alloys are many, but whatever they may be the idea is the same, viz: A wire having good carrying capacity which melts at very low temperature. Some of the alloys are as follows:

TABLE V.

Bismuth 20 parts, lead 20 parts, mercury 60 parts; melts at 20 degrees Centigrade.

Tin 50 parts, bismuth 50 parts; melts at 160 degrees Centigrade.

Tin 67, bismuth 33; melts at 166 degrees Centigrade.

Tin 80, bismuth 20; melts at 200 degrees Centigrade.

Cadium is used by some fuse manufacturers, though the percentage is small. The alloys are not given with any idea of their being of practical benefit to anyone in the making of fuses, but merely to give you a better idea of what a fuse really is, and at what temperature it melts.

Cent. to Fahr. and vice versa. To obtain the melting temperature in degrees Fahrenheit, multiply the degrees Centigrade by

1.8 and add 32, thus: 200 degrees Centigrade is $(200 \times 1.8) = 360 + 32 = 392$ degrees Fahrenheit. Conversely, to reduce Fahrenheit to Centigrade, subtract 32 and divide the remainder by 1.8.

The size of the fuse on any circuit must be proportionate to the current used thereon.

From what has been said it is readily seen that in order to have adequate protection the size of the fuse on any circuit must be proportionate to the current used thereon. There would be no protection, or practically none, in using a ten-ampere fuse on a circuit, the wires of which are only rated at five amperes. There would be no protection to the lamps or motors of a circuit if their combined current consumption were but five amperes, and the fuses were ten amperes capacity, even though the wires themselves be heavy enough to carry ten amperes.

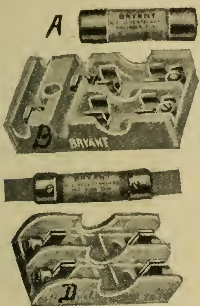
It sometimes happens that only half a dozen or so of lamps are installed on a circuit of large wire, say No. 10, which is rated at 24 amperes. Now, suppose such a circuit carried but ten 16 c.p. lamps, requiring $.51 \times 10 = 5.1$ amperes, and that for some reason there was a sudden rise in the voltage sufficient to force an ampere of current, instead of the lamp filament's capacity of .51 of an ampere, through each lamp. Suppose also the fuses were of 10 ampere capacity, instead of five, which latter would equal the combined capacity of the lamps. The wires would not be injured in the least in this case. The lamp filaments, however, would be forced to double their capacity, and would quickly be burned out. It, therefore, follows that only fuses of carrying capacity equal to the current actually being used on the circuit should be used, where motors or incandescent lamps are attached to the wires.

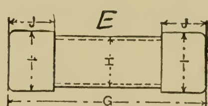
With the projection lamp, however, unless the wires be in excess of No. 6, or local law restricts the amperage one may use, only the wires themselves need be protected, since there is nothing about a projection arc lamp which will be in the least injured by any amperage up to the capacity of a No. 6 wire, or, for that matter, up to 60 amperes.

It must be taken into consideration, however, that ordinarily fuses will carry a considerable overload for a time, and some overload all the time.

They will probably carry a 10 per cent. overload permanently and a 33 1-3 per cent. overload for a short time, though this cannot always be depended upon. From this it follows that incandescent lamp or motor circuits should not be over-fused at all, no matter how large the wires may be.

While Fig. 19 shows the manner in which fuses are installed in the line, it is no longer permissible to use raw fuse wire, except in certain kinds of porcelain receptables, though this was done up to less than ten years ago. Now, however, there are safety fuses, known as "Cartridge" and "Plug" fuses, and the Underwriters' rules make their use, in most cases, compulsory. An exception may be allowed in the operating room, where "Link" fuses may be installed in a metal cabinet with self (spring) closing door.





Amperes	G	H	I	J
0-30	2 inches	$\frac{1}{2}$ inch	$\frac{9}{16}$ inch	$\frac{1}{2}$ inch
31-60	3 inches	$\frac{3}{4}$ inch	$\frac{13}{16}$ inch	$\frac{5}{8}$ inch

Fig. 20.

The cartridge fuses, shown in Fig. 20, are simply a fuse wire, or strip of fuse metal, enclosed in a cylinder of fiber which is packed full with some non-inflammable substance. The wire, or strip attaches to the brass or copper contact at either end, and the two contacts in turn make contact with the brass or copper clips of the fuse block. A, Fig. 20, shows one type of cartridge fuse in common use for circuits up to 60 amperes, B being its receptacle. C shows what is known as the "knife" cartridge fuse, used mostly on heavy circuits. D is its receptacle, A being forbidden on circuits carrying more than 60 amperes; type C, Fig. 20, must be used. E, Fig. 20, and the table below it, gives the necessary dimensions of the various parts of fuses, such as A, Fig. 20. Reject any fuses which do not measure up to the requirements of the table. F, Fig. 20, shows fuse contacts designed to be clamped under binding post screws, the same as are link fuse contacts.

When using cartridge fuses be sure that the contact clips are clean and that the fuse contacts make good contact with the block contacts. Cartridge fuses are perfectly safe for use anywhere. The barrel and contacts are of no value whatever, after the fuse is blown. Throw them away promptly lest they get mixed with your good fuses and cause trouble and delay. It is not always easy to be certain whether a cartridge fuse is blown or not by looking at it. There is a small, round spot in the center of the paper label which is supposed to break open when the fuse blows, but it does not always do it; also sometimes the hole is open, or seems to be, and the fuse is not blown.

Throw the old fuses away and then there will be no mixing with the good ones, with consequent vexatious delays trying out fuses.

In giving this advice, I am fully aware of the fact that it is physically possible to refill both the plug and cartridge fuses, and that some exhibitors have been in a habit of having their old cartridge fuses refilled. Nevertheless I advise against this practice since it is, in a measure, dangerous unless the refilling be done by thoroughly competent men. You do not save very much by having fuses refilled and should the operation be performed by incompetent mechanics serious trouble might result.

There is at present a move on foot to prevent the refilling of any kind of fuse.

Another excellent type of safety fuse, in very common use, is what is known as the "Plug" fuse, as shown in Fig. 21.

Fig. 21.

At A, Fig. 21, we see a plug fuse, consisting of a porcelain body, a brass or brass and mica cap, and two brass contacts, one screw-shaped and one small flat button in bottom of the plug. The fuse, shown at C, is a piece of fuse wire attaching to the button, passing up and over a porcelain wall and attaching, at its other end, to the brass screw. The receptacle, which comes in many forms, is shown at B. D is a special form of plug fuse, made to use on amperage between 35 and 60. Plug fuses in regular form are not made in capacity exceeding 35 amperes. They are not made in any form for capacity in excess of 60 amperes. The high, porcelain cap in D allows of the use of a much longer fuse wire. Plug fuses may be used for any kind of work, up to the limit of their capacity. They are perfectly safe, and somewhat cheaper than the cartridge fuse.

There is still a third type of fuse called the "Link Fuse," which is, for certain reasons, very well adapted for use on projection lamp circuits. This type is shown in Fig. 22, in various sizes and shapes.

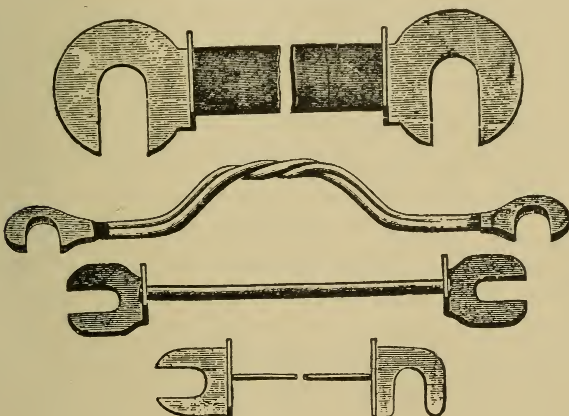


Fig. 22.

The advantage of the link fuse for projection circuits is that it is very largely fool-proof. With both the plug and cartridge fuse it is quite possible for operators, with more cunning than judgment or sense, to increase their amperage almost indefinitely by placing a copper "jumper" in the terminals in such manner that it is under the fuse, hence out of sight. It can only be detected by close inspection. The plug fuse is "boosted" after the same fashion by placing a bit of metal, or a copper penny inside the receptacle and screwing the plug down on it in such manner that the two contacts are connected by the copper. Such schemes as this render the fuse of no value and leave the circuit to all intents and purposes entirely unprotected. Such practices are reprehensible in the extreme. Any operator, or other person, caught boosting fuses (it is termed "boosting" the fuse), should be discharged instantly and his license taken away, if he has one.

It is practically impossible to put a booster in a link fuse without its presence being instantly detected. For this reason the Department of Water Supply, Gas and Electricity of the City of New York have issued a rule compelling the use of link fuses in operating rooms where the current used exceeds the capacity of an ordinary plug fuse, viz: 35 amperes. It should be required for all operating room circuits, regardless of amperage used. Fuse blocks and switches may be had with fuse binding posts made to carry link fuses.

To Sum Up: Never fuse above rated capacity of the wires. Never fuse an incandescent circuit for more than the combined current capacity of its lamps. Never fuse a motor circuit more than 10 per cent. above rated capacity of the motor, or motors. In fusing the projection circuit, or circuits, unless local law limits the current flow on such circuits, fuse ten amperes over the normal pull, up to 45. For anything in excess of 45 use 60 ampere fuses. This advice is given with the understanding that nothing less than No. 6 wire be used on any part of a projection circuit. *Never, under any circumstances, boost a fuse.* If you should get caught without a fuse or without a fuse of low enough capacity to properly protect the circuit, you may, provided you have one fuse of proper size, install on one leg of the circuit a large capacity fuse, or may even bridge the two binding posts with wire *temporarily only.* The circuit will be fairly well protected by the one fuse of proper size and you must get another one for the other side as soon as you possibly can. Such a condition is very bad, and must only be tolerated temporarily in case of emergency. But such cases of emergency should be of very rare occurrence, since you always should have an ample supply of fuses on hand. It is, of course, understood that if more than 60 amperes are used on the projection circuit, it will be fused accordingly.

When a fuse blows, remove the old one and *throw it away.* It is, as has been said, of no value whatever. It may get mixed with the good ones, if kept, and cause you much annoyance later. Install a new fuse. If it blows immediately, or within a few moments, it is conclusive proof there is trouble on the wires of that circuit, which must be left dead until the trouble is remedied. You may force the circuit to work by installing a couple of larger fuses, but in so doing you run the risk of setting fire to your house. You will very likely find the trouble exists in the form of a ground or a limited short circuit due to something of very limited current carrying capacity being placed across the wires at some exposed point. A ground, however, is most likely the cause of the trouble.

Sometimes a cartridge fuse will blow and it is difficult to tell which one of the two it is. The fuses may quickly be tested. with a test lamp made as follows: Strip the insulation from half an inch of a piece of heavily insulated wire. Solder the raw end of the wire to the brass ferrule contact of an incandescent lamp of any c.p., but of the voltage you are using. Carefully and completely cover the wire end and ferrule with insulating tape, leaving the button contact in end of lamp bare. Attach other end permanently to one of the wires, or bars in your switch cabinet. To test a fuse touch one end of it to wire, or bar of opposite polarity to one wire it is attached to, and then touch lamp button contact to other end of fuse. If lamp lights, fuse is O. K. If it does not light, fuse is blown. This idea is illustrated in better

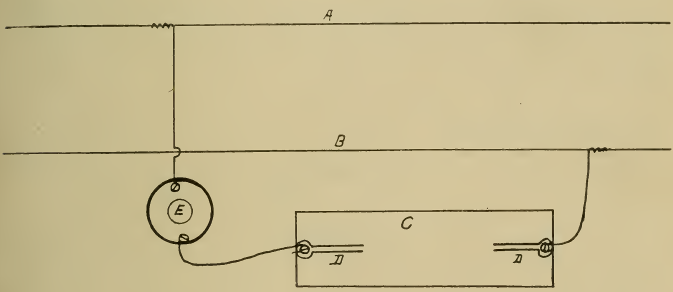


Fig. 23.

form in Fig. 23, in which A—B are wires of opposite polarity. C is a knife cartridge fuse block and D—D its contacts. E is an ordinary incandescent lamp socket, connected as shown, a lamp of the voltage used, but any c.p. is inserted in socket E. It will readily be seen that if a good fuse be touched to contacts D—S, lamp E will light, but if the fuse be a bad one, lamp E will not light. Such an arrangement is easily made, but block C should have contacts for ordinary or knife cartridge fuses, or plug fuses, according to which you are using. Install it in the switchboard cabinet and it will be found to be a great convenience.

All Fuses Are Stamped with Their Rated Capacity, except link fuses. Cartridge fuses voltage and amperage ratings are usually found on the paper label on their barrel. Plug fuses have the rating stamped on the brass cap.

Fuses Are Ordinarily Installed as Follows: (a) Main service fuses, which are located ahead (on the street side) of the main switch. These fuses carry the entire load of the house, except the exit lights and others ordinarily left burning during the performance. Circuits carrying such lights should be attached to the feed wires ahead (on the street) of everything else, and have main service fuses of their own. (b) Fuses on the main switchboard carrying the operating room projection circuit. (c) Fuses on the main switchboard carrying feed wires for the stage, if stage circuit passes through main switchboard. (d) Main fuses in operating room carrying all circuits, and individual circuit fuses also. (e) Fuses on each individual incandescent circuit, same being usually located on main switchboard. (f) Fuses on stage switchboard for each individual circuit, as well as main fuses carrying all circuits, except exit and emergency light circuits. *Every circuit, no matter how large or how small, must be protected by its own individual fuses,* in addition to the main fuses. Plug or cartridge fuses are the only types allowed on any stage.

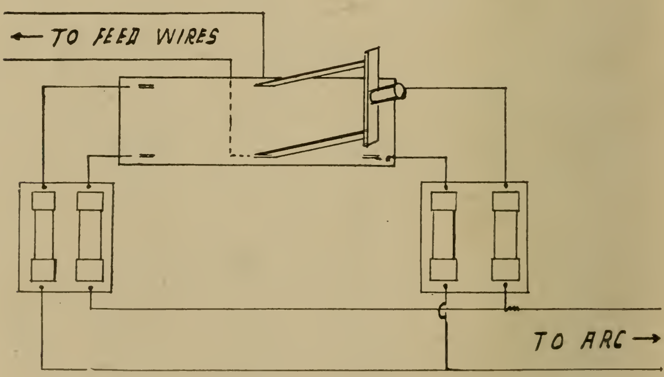


Fig. 24.

Fig. 24 illustrates an excellent method of installing projection arc and main house fuses. It does not necessarily follow that because a fuse blows there is anything wrong, especially if one is not fused much above the actual amperage being used. By installing an auxiliary set of fuses as per Fig. 24, one has only to throw over the switch instantly to get current again through another set of fuses.

The Operating Room

IN a motion picture theater the operating room is naturally of great importance, since from it comes the greater portion, if not all of the show. It is therefore vitally necessary that it be carefully located, and constructed along intelligent lines. The iron-lined "coop" of the past, stuck up in any corner not of use for something else, is rapidly disappearing. The manager who has kept pace with the times fully realizes the fact that, if excellence in results is expected, a well ventilated, roomy and at least fairly comfortable operating room must be provided. No man of sound sense will expect an operator to produce the best possible results working in a cramped, ill ventilated, insufferably hot "coop." It is not in the nature of things.

As has been pointed out many times by the writer, really high-class projection is the product of brains. It requires incessant care on the part of an operator, and constant, unremitting attention to the smallest details to produce excellence on the curtain and *keep it there*. Not only does it require constant care, but it also requires knowledge and the application of intelligence of no mean order. Men who can produce results on the screen of such excellence as to satisfy the critical, have knowledge and brains sufficient to enable them to earn a good livelihood at other callings. They therefore do not have to, and usually will not work in any but decent surroundings.

Moreover, even the operator of mediocre ability will produce better results when working in a comfortable, well ventilated room than he will in a "coop." It requires only the application of reasoning power and a little common sense to understand that. Therefore managers will do well to carefully consider the construction of their operating rooms, even, if necessary, sacrificing other things to some extent in order to secure a good sized room, and have it, above all things, well ventilated. It is a matter vitally affecting their projection, hence, also, the box office income.

Given good equipment, and decent, comfortable surroundings, with proper, adequate ventilation, the operator can have no valid excuse for failure to deliver satisfactory, high-class results on the screen. Cooped up in a little iron-lined sweat-box, he has a very plausible and very evident excuse for poor projection, and if, in addition, we add indifferent equipment, coupled, as it usually is, with parsimony in the matter of supplies, tools and accessories, good results on the screen become a practical impossibility. It then follows, as the night follows the day, that the box office receipts will suffer. Hence a poor operating room, with inefficient equipment and inadequate supplies, therefore, either or all together, are incontrovertible evidence of lack of business judgment on the part of the management. These shortcomings have caused the financial failure of many a house which would otherwise have succeeded.

SIZE OF THE OPERATING ROOM

As a general proposition, the larger the operating room, within reasonable limits, the better. But the least size which should be even considered is: For one machine—six feet width by eight feet front to back, with three feet six inches of additional width for every additional machine, stereopticon or spotlight. No operating room to be less than seven (7) feet in the clear from floor to ceiling. Seven feet is too low for the ceiling, but it can be made to do fairly well if there be ample ventilation, along the lines hereafter described. However, if it is possible to secure a high operating room ceiling it should by all means be done.

More and more the authorities are demanding fireproof operating room walls, and in this they are absolutely right. However, the laws passed to date, designed to secure the same, are largely a farce, for reasons which I will explain. In many cities, and in some states, laws have been passed requiring operating room walls to be constructed of fireproof material, the great majority specifying asbestos, or its equivalent; some requiring asbestos and making no allowance for anything else. I might here remark that I very much doubt any court upholding such a law. By no stretch of the imagination could a thin wall of asbestos, supported on comparatively weak angle irons, be adjudged the superior of a brick or concrete wall for fire resisting purposes. But be that as it may, the laws are wrong in that no adequate means for the instant closing of wall ports is provided by any law the writer has seen to date, and in but few, if any, is adequate means for carrying off the flame and smoke provided. True, a few laws specify a vent pipe, but in every instance the specification is totally inadequate as to size, or else a fan is depended on to create sufficient suction to perform the office. Film burns with great rapidity. It gives off a vast volume of dense, pungent smoke, as well as much gas. An audience ordinarily is not injured by the fire itself. It is the frenzy of the alarm, as the smoke or flame, or both become visible, that is dangerous to the audience. I will describe an operating room construction such as will allow of the burning of a film, or half a dozen of them, absolutely without the audience being in the least alarmed. It is even probable they would not know of the fire at all until it is over.

The ideal operating room wall is of concrete, preferably reinforced, six inches thick, arched over the top and having a floor also of concrete. This makes a solid stone room, with no opening at all, save the door, the necessary holes in the front wall and the vent-pipe opening. The only possible objection to such a room is its weight. It is not always available for use in existing theaters on that account. If well reinforced the walls may be only four inches in thickness.

Next to this comes brick walls, laid in cement mortar and arched over the top, the bottom of the arch held from spreading by suitable iron tie rods; the floor of concrete. Next in order comes four or six inch hollow tile, laid in strong cement mortar, the ceiling either arched over or constructed exactly the same as are flat tile roofs, minus the top coating of tar paper and gravel, of course.

No official could possibly object to rooms thus constructed, provided the workmanship be first-class. If any official did object, certainly no court would uphold him in it. However, it may not be worth while to oppose the local officials, even though they be totally unreasonable. I assume that before proceeding to construct a room after my directions you will secure the approval of the local authorities.

There are, however, a few instances of local, or state laws which are worded in such manner as to exclude, for operating room wall construction, everything but asbestos supported on an iron frame work. Usually such laws specify the hard asbestos, usually known as "asbestos board," but at least one state, Connecticut, is satisfied with the ordinary soft, sheet asbestos.

I think there can be no question but that a law, excluding brick, cement or hollow tile would not be upheld by the courts. Certainly where adequate foundation can be had, either concrete, brick or hollow tile walls for operating room is far superior to asbestos. Either one possesses fire resisting qualities fully equal to asbestos, considering relative thickness, and has far more stability and solidity.

Taking these facts into consideration it is extremely queer, not to say downright suspicious, that laws so worded that brick, tile, concrete, and any other material than asbestos for operating room construcion is excluded are enacted, and that rules along these lines are made by department officials. This looks all the more queer when one considers that there are those engaged in the construction and sale of ready-to-set-up operating rooms, made usually in exact accordance with the law—before the law, or rule, is passed or formulated. Moreover a good, stiff price is charged for these rooms, not one of which is fireproof in any true sense. They will confine actual property damage to the operating room, probably, but the dense, pungent smoke must perforce go directly into the auditorium. Also tongues of flame are likely to creep out through every crevice—result: a wild stampede on part of the audience.

A REAL FIREPROOF OPERATING ROOM

I will now describe what will constitute a real fireproof operating room, though only general instructions, not detailed, are given as to the actual mechanical matters pertaining to the proper wall construction.

Before following these instructions consult the requirements of local and state laws.

If walls are to be of brick, with arched ceiling, they must be not less than eight inches thick, of good, sound, whole brick, laid in lime mortar mixed in the usual proportions and strongly tempered with cement. It is, of course, assumed that a solid, substantial foundation can and will be provided for the walls. The wall openings must be carefully located and built in. The ceiling arch must be tied at its base with iron tie-rods ¾ inch in diameter, spaced not more than three feet apart. These rods must extend through either wall, at base of ceiling arch, and through plates of iron ½ inch thick, by not less than four inches square, the idea being to prevent the weight of the arched brick ceiling from spreading the walls. The details of tying the arch may safely be left to any competent brick mason. The ceiling arch may be of hollow tile, if preferred, or may be of hollow tile laid the same as for flat tile roof construction, using I, T or L irons to support the tile. But in any event the ceiling, whether arched or flat, of brick or tile, should be laid in mortar very strongly tempered with cement.

It is possible to secure enameled brick of almost any color and, while comparatively expensive, a room faced with such brick presents a very handsome appearance. It would be ideal from any and every point of view. If walls are of common brick they may be plastered and finished to conform with the general sheme of house decoration. Cement rooms need little or no special instructions. The walls may be as thin as 4 inches, provided they be well reinforced, in the usual way, with iron. If not reinforced they should not be less than six inches thick. The outer surface may be paneled, in the making, or finished in any desired way. Interior walls need only to be painted some dark color. Cement shelves may be provided in convenient location.

Hollow tile walls have the advantage over brick and cement in lightness. The instructions given for brick apply equally to tile, as to tie-rods, mortar, etc. Hollow tile walls and ceiling should, and must be plastered within and without with cement mortar.

The foregoing embodies only general suggestions. I assume that, knowing what is wanted, any good mason contractor can and will construct the walls and ceiling in good shape without specific instructions on every point. But now we come to matters of greater detail.

Floors for Brick, Tile or Cement Wall Rooms. Floors for such rooms should consist of not less than three inches of concrete mixed in the usual manner with cement, sand and water, stone to be crushed to pass a ¾ screen. This concrete should be spread evenly, tamped down and be covered with a top dressing of cement not less than ¾ inch in thickness. A room built of brick, tile or cement, having such a floor, and ceiling of brick, tile or cement, will be absolutely impervious to any operating room fire. Also, as the walls and floor will quickly become perfectly dry, they will be, to all intents and purposes, insulating. Of course, it will be found a practical impossibility to construct such a room in many existing houses, owing to its weight. However, I strongly advise that houses constructed in the future be provided with such rooms. If foolish department rules or laws stand in the way, it is high time the courts be invoked to wipe them out.

The available fireproof room for present theaters, in which proper foundation for operating room with walls, as before described, cannot be provided, is asbestos board, held in place by a suitable iron frame. The present New York State Law is perhaps as good as any, so far as the mere mechanical construction goes. It is as follows:

Extract From New York State Laws, Chapter 25, 1911.

General Specifications: Such booth shall be constructed with a framework of angle irons not less than one and one quarter inches by one and one quarter inches, by three sixteenths of an inch thick, the adjacent members being joined firmly with angle plates of iron. The iron

> members of the frame shall be spaced not more than four feet apart on the sides and not more than three feet apart on front, back and top of such booth. The fire resisting material provided for in section 209 of this article (iron frame covered with asbestos board or some equally strong and fire-resisting material) shall completely cover the sides, top, and all joints of such booth. The sheets of such fire-resisting material shall be at least one quarter of an inch in thickness, and shall be securely attached to the iron frame work by means of iron bolts or rivets. The floor space covered by such booth shall be covered with said fire-resisting material not less than three quarters of an inch in thickness. There shall be provided for the booth a door not less than two feet wide by six feet high, consisting of an angle iron frame covered with sheets of said fire-resisting material one quarter of an inch in thickness, and attached to the booth by hinges, in such manner that the booth shall be kept closed at all times when not used for ingress or egress. The operating window, one for each machine to be operated therein and one for the operator thereof, shall be no longer than is reasonably necessary to secure the desired service, and shutters of said fire-resisting material shall be provided for each window. When the windows are open the shutters shall be so suspended and arranged that they will automatically close the window openings upon the operating of some suitable fusible or mechanical releasing device.

It will be observed that this is a very clumsy effort on the part of legislators to do something concerning which they had little or no practical knowledge. However, the specifications for wall construction are fairly good. In addition thereto I would suggest that it be required that all joints in the fire-resisting material should come over an L or T iron; that bolts holding same to frame be spaced not more than six inches apart; that 3/8-inch asbestos board is much more suitable for such work than is 1/4 inch. I would also suggest that a door arranged to slide on a sloping track, in such manner as to remain normally closed by gravity, is far superior to hinges and a spring. I would also suggest that such a floor should be very carefully and thoroughly supported, since any vibration will produce bad results on the screen.

Rigid Floor.—It is important that the operating room floor be perfectly solid and free from vibration. Many pictures vibrate on the screen for no other reason than that the operating room floor is not solid. Suppose your operating room floor vibrates all over, evenly, just one sixty-fourth of an inch. It means that your whole picture is jumping up and down just that much. The net result would scarcely be visible on the screen. Suppose, however, the floor vibrates in such manner as to move the head of your machine in a teetering fashion the same amount. You have a throw of perhaps 100 feet. The movement would then be very perceptible on the screen. This is illustrated in Fig. 25; 1,

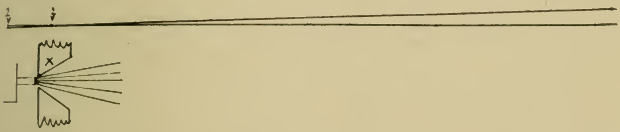


Fig. 25.

representing back of machine table, 2 being the projection lens. It will readily be seen that any movement of the machine table, front and back, is magnified to huge proportions on the screen.

This illustration will serve, I believe, to impress upon the reader's mind the prime necessity for a solid operating room floor, free from all vibration.

OLD STYLE CONSTRUCTION

While I by no manner of means approve of such construction, and strongly advise against it, for the sake of completeness, it is necessary to give some instruction as to the old style "fireproof" walls of lumber and metal. Such a room may be constructed by building a framework of studding, the same as for any other room, covering same, inside and out with rough one inch lumber. Over this lumber, on the inside of the room, lay sheet asbestos not less than ¼ inch thick, with joints overlapping. Over this place sheet metal, not less than No. 20 gauge. Both the asbestos and metal must overlap at all joints. Metal must be nailed firmly at all joints and seams, nails spaced not to exceed one inch apart on all seams. Ceiling and floor may be of substantially the same construction, covered with asbestos and sheet metal in the same manner. Such a room is in no true sense fireproof. It is but a makeshift at best, though better than no fireproofing at all. It is an ugly, hot substitute for a real fireproof room, and is not approved by the Underwriters' Association. A much better plan than using iron is to us asbestos board, covering all seams with a backing of sheet asbestos.

Remember that in thoroughly fireproofing your operating room you are not only protecting your own property from possible destruction, but you are protecting your patrons, the audience, as well as the adjoining property. More than this, you are protecting the business, as a whole, from the sensation-seeking newspaper, which makes all possible capital of every operating room fire.

You must also remember, however, that fireproof walls, ceilings and floors most emphatically do *not* constitute a fireproof operating room in the true sense of the word. As has been said, it is seldom the actual fire which is dangerous to the audience. It is the alarm, with its consequent stampede. The real fireproof operating room will therefore be one which will not only confine the property damage within its walls, but also prevent the audience from knowing there is a fire in the theater. Given real fireproof walls this is a comparatively simple matter. It is so simple that the struggles of law makers with this subject become utterly ridiculous and absurd, when one knows the answer.

To Recapitulate—The walls may be of concrete, brick, hollow tile or asbestos board on an iron frame. The ceiling must be supported in such manner that it will not become weakened and fall through effects of an operating room fire. The floor must be as thoroughly fireproof as the ceiling and walls, solid and entirely free from vibration and of insulating or semi-insulating material.

OPERATING ROOM OPENINGS

There must be a door not less than two feet wide by six feet high, one lookout and one lens port for each machine, and one combined lookout and lens port for the spotlight, if one there be, except that if the machine be a combined motion picture projector and stereopticon dissolver, then one small lens hole, one long lens hole and the one lookout port is all that is necessary.

The lens holes need be only large enough to clear the light ray. If the machine sets close up to the wall the lens hole may be somewhat smaller than if the lens is back a foot or two from the wall. This is because the light rays begin to spread after leaving the lens. If the wall is a thick one it is well to flare it outward as shown at X, Fig. 25. If the drop from operating room to screen be considerable the holes should, if the wall be a thick one, be sloped downward through the wall. This slope should be at the projecting pitch. With a thin wall, where the lenses are close to the wall, a round hole three inches in diameter is ample for each lens. It is also ample for a thick wall, provided the holes be made as per X, Fig. 25. If the lenses are located back some distance from the wall the holes will have to be larger. For a dissolver one long lens hole is better than two small ones. For a single machine with stereopticon attachment, not dissolving, a single port for both lenses is better than two. For the spotlight the hole should be not less than fourteen inches in diameter, round or square. Round holes present the neatest, most finished appearance from the auditorium side, but are not the best for machine observation ports, though all right for stereopticon observation ports. If these directions are followed clear through there is no necessity for making holes very small. However, there is no necessity for making them larger than is required either.

The Operator's Lookout Port for the moving picture machine is something with which excellence in projection is intimately connected. Its size is of the utmost importance. If projection of high class is to be had, it is imperative that the operator have a clear, uninterrupted view of every portion of the screen, from either sitting or standing operating position, at all times. In operating position the eyes of the operator will ordinarily be from two to three feet from the wall. It therefore follows that if the port be too narrow he will be unable to see both sides of the screen with both eyes at once. It follows, also that, within certain limits, the necessary width of port will depend on the length of the throw. That is to say: a short throw and a wide picture, will render necessary a wider port than will a long throw or a narrow picture. This should be taken into consideration in constructing the room.

If a man is working eight hours a day, running one reel after another, the work is trying under the best conditions, particularly on the eyes. If the observation port be so located, and of such height that he is obliged to remain seated all the time, or else stand in stooping position, it adds largely to the labor and, moreover, detracts largely from the excellence of curtain results, as well as adding unnecessary strain to the eyes. I cannot impress too strongly on my readers the absolute necessity for an ample, well located lookout port for the motion picture machines. If you expect an operator to do his best work while craning his neck to look through a little, inadequate knot hole in the wall, you will most surely be doomed to grievous disappointment. It is not in the nature of things.

Local or State Laws in many instances limit the size of the openings, instead of protecting them. Such a course merely emphasizes the lack of real knowledge on the part of law makers,

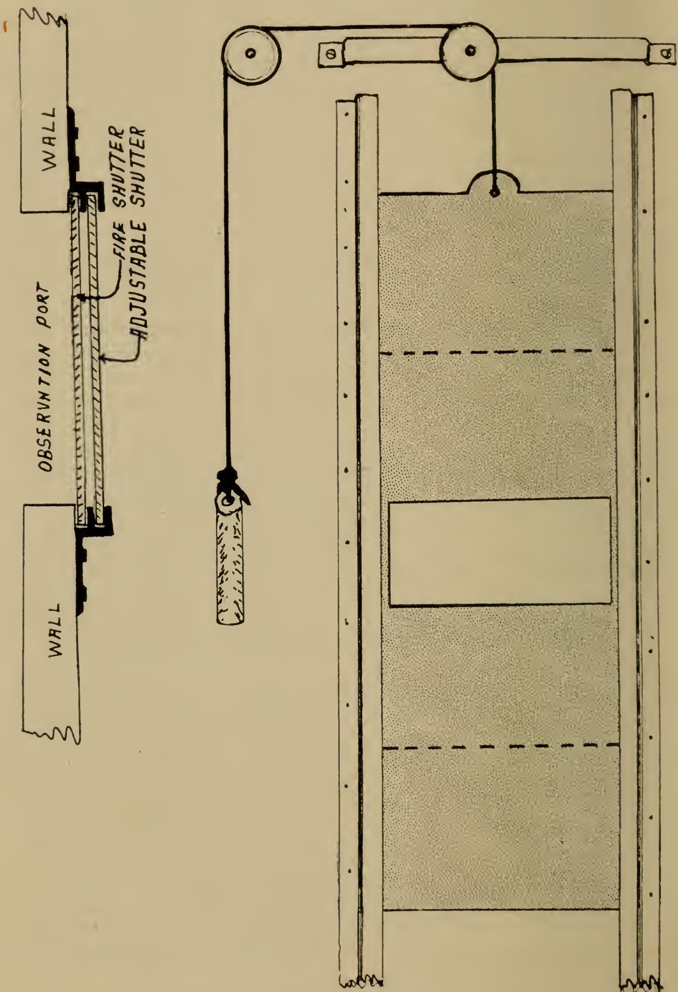

WALL
FIRE SHUTTER
ADJUSTABLE SHUTTER
OBSERVATION PORT
WALL

Fig. 26.

Such rules or laws must, of course, be obeyed, unless one wishes to carry the matter into the courts, but every effort should be used to secure sensible legislation. I speak thus for the reason that I regard excellence in projection as a practical impossibility without observation ports of ample size. Of course, an operator *can* give his best work under adverse conditions. The point is, however, *he won't.* It is not human nature to do so.

I cannot give any universally applicable rule for sizes. With a short throw and a wide picture, as much as 15 inches may be advisable for observation-port width, but this is only in extreme cases. Probably twelve inches in width will be ample for ninety-nine per cent. of cases and in a great majority of cases ten inches wide will serve every purpose. However, there is really no good reason why the port should not be twelve inches wide; and therefore, why not adopt that as a standard width for machine observation ports. As to height: the port should be of such height that a man six feet tall can just see the top of the picture when standing up, in ordinary operating position. It should extend down far enough so that a short man can just see the bottom of the picture when seated in ordinary operating room position.

This, of course, makes a very large port (about 12 x 24 inches), but if this is deemed objectionable it is easily cut down to an adjustable port 12 x 6, or 12 x 8 inches, such as is illustrated in Fig. 26. The sketch is, I believe, largely self explanatory. The large view shows the adjustable shutter hung by a counterweight so that the operator can move it up or down to suit. At the left is a top view showing the fire shutter back of the adjustable shutter. Thus the one does not in any manner interefere with the other, the fire shutter being, of course, pulled clear up so as to uncover the entire opening.

In closing this topic let me again impress upon exhibitors and managers the vital necessity for ample observation ports. The sliding shutter takes away your only excuse for a small hole. If you still persist in the small-hole idea, blame no one but yourself if you have shadows on the screen. My advice is that if your observation ports are of less size than I have indicated, make them larger immediately and thus give your operator a chance to do good work.

The stereopticon and spotlight ports are not of so much importance, since ordinarily one uses them but a short time and can put up with some inconvenience for a few moments occasionally, if necessary. An observation port ten inches in diameter, if round, or the same measurement square, is ample for the stereopticon. There is nothing to be gained by locating the ports in such manner as to be a continual inconvenience to the operator. There is much to be lost by so doing. An hour's time spent in careful, intelligent study of the matter, when planning an operating room, will make the operator's work far more pleasant and enable him also to give better service. It will produce far better results on the screen every time the machine is used.

WALL FIRE SHUTTERS

Wall fire shutters are of the utmost importance since they, together with adequate vent-flue and fireproof walls, offer not only absolute protection against fire damage outside the operating room, from any film fire, but also against any probability of alarm on the part of an audience from fire in the operating room. This latter is of supreme importance since it is seldom the fire itself that causes loss of life or injury to an audience. It is the panic which almost invariably follows an alarm of fire in a theater, or other place where an audience is gathered. Ninety-nine times out of every hundred there is ample time and opportunity for an audience to escape in perfect safety, did it act rationally and sensibly. The fact is, however, that an audience seldom or never does act rationally when an alarm of fire is given, particularly if fire or smoke is actually visible. Given a glimpse of fire or smoke and an audience may usually be depended upon to go stark, raving mad.

I wish to impress upon my readers the fact that it is entirely practical and feasible to prevent any glimpse of fire or smoke from an operating room fire by the audience.

Fire shutters should and must be installed which will instantly and automatically cover every lens port and lookout port in the operating room wall, the instant a fire starts. Heretofore practically all wall shutters installed have been in the nature, more or less, of a bluff. In no instance, so far as the writer knows, have they been installed in such manner as to close practically the instant a fire starts—a matter of prime importance, since once the audience gets a glimpse of the smoke or fire the mischief is done. In many cases a large majority, in fact all the shutters I have observed, besides being held in such manner that the fire must gain large headway before they automatically drop, will not work at all, or they work so poorly that they are of very slight benefit. It may, of course, be said that the operator should himself drop the shutters the instant fire starts, which is very true. What the operator should do and what he *will* do under those conditions are two very different matters, hence the shutter dropping should be entirely both automatic and instantaneous. The exhibitor or manager who, through false economy, lack of knowledge, or carelessness, neglects this most important detail of his operating room equipment, is subjecting his audience to needless danger, and himself to possibility of loss, perhaps of his entire theater, as well as endangering adjoining property. Municipal authorities ought to compel the installation of proper shutters, and attach a heavy penalty for the failure of any one of them to work perfectly at any time. Swinging shutters should not be allowed. They are ineffective and of little or no value.

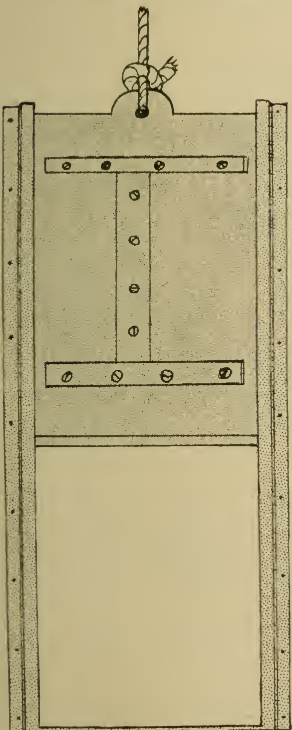


Fig. 27.

Shutters may be of metal, or of hard asbestos board. If metal they should be not less than 1/16 inch thick; if of asbestos board not less than ⅜ inch.

If asbestos board be used for a shutter larger than 12 x 12 inches it should be held perfectly flat and prevented from warping by having 1 x ¼-inch irons bolted to one side as illustrated in Fig. 27.

The shutters should be hung in metal grooves. These grooves should be so made that the shutter will overlap the edges of the opening by not less than ½ inch top, bottom and sides, when closed. The grooves should extend from ½ inch from lower edge of opening to at least twice the height of the opening, thus: if the opening be 10 inches high then the grooves should extend at least ten inches above top of opening, or twenty inches over all. At top of grooves must be fixed a stop which cannot be removed, to prevent raising shutter out of grooves. This is important, since, with short grooves and no stop, operators will frequently raise the shutter partly out of its grooves and cant it over so that it binds and hangs on top ends of grooves. The shutter is thus of no effect.

One thing is absolutely necessary in installing wall shutters, viz: the grooves in which the shutters slide must be perfectly

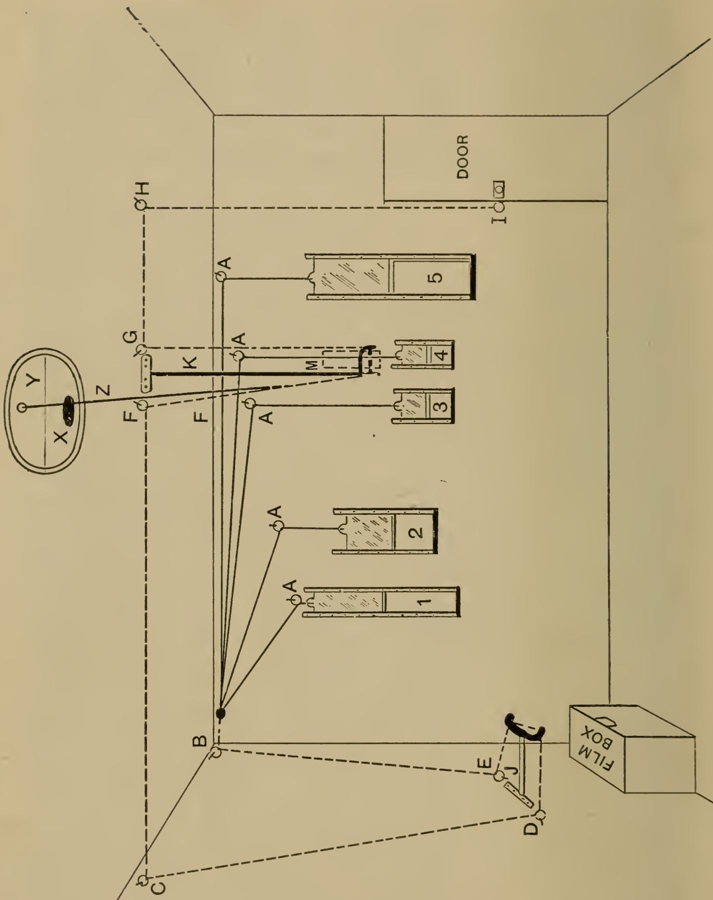


Fig. 28.

straight and true, so that they may fit the shutter snugly and yet not bind in the least. As a matter of fact, wall shutters should rest in a cast iron frame in which straight, true grooves are plowed. This is, however, hardly practical since openings are of such different shapes and sizes. It would not be impractical, however, or excessive in cost, to have a machine shop make shutters and frames with grooves all ready to be bolted over the various openings. The average sheetmetal worker, it seems, either cannot or will not make shutters and shutter grooves that will work right. If for any reason, as often is the case, it is found impractical to raise the shutters over the top of the openings, they may be arranged to slide sidewise. In this case they must be held normally closed by a very flexible coil spring.

Remember that shutters which do not work freely in their grooves are useless. They absolutely must drop instantly, and every time, when released.

Having properly fitted the shutters in their grooves so that each and every one works perfectly free, yet is not too loose in its grooves, the next thing is the method of their working. Times almost without number have I seen excellent shutters, which were well fitted and worked freely, dropping instantly when released, but which were of slight effect because of improper or ineffective means for their automatic closing instantly a fire started. Remember that it will not accomplish the purpose to have the shutters close a minute or two after the fire starts. They must drop *instantly* the blaze starts. This is readily accomplished, as follows:

(a) The shutters must all be sustained (held up) by one master cord, strong, yet fine enough, and of such nature as to burn in two instantly. *This master cord should be soaked in some highly inflammable wax.*

(b) The master cord must be brought down directly over, and within six (6) inches of each machine aperture and down over and within twelve (12) inches of the film-box, and down over and within twelve (12) inches of the rewinder, if same is within the operating room, being held over each aperture, film box and rewinder on a spreader.

(c) The bottoms of all shutters must be padded with rubber or felt, or whatever they rest on when closed must be so padded, to deaden the sound of their closing when dropped suddenly. A loud clatter of falling shutters would instantly attract attention directly to the operating room.

In Fig. 28 we see a set of shutters properly installed and suspended. The dotted line represents the Master Cord, to which all other cords are attached. 1, 2, 3, 4 and 5 are respectively the dissolver lens hole, dissolver lookout port, machine stereopticon lens opening, machine projection lens opening and machine lookout port. A-A-A-A-A-B-C-D-E-F-G and H are ordinary one inch iron harness rings. K is an iron bar attached to the ceiling, terminating at its lower end in a fork with holes through which the master cord passes. J is a similar spreader attached to the wall immediately over the film-box. I is an iron ring attached to the end of the master cord and slipped over a headless bolt, or spike driven into the wall beside the operating room door latch. M is the upper machine magazine. The spreader comes down just back of it, immediately over the machine aperture. Instead of attaching to ceiling it may be fastened to the front of the upper magazine.

A moment's study of the diagram will show that should a fire start at the machine, the master cord, being saturated with inflammable wax, would *instantly* be severed by the blaze, thus releasing all shutters and at the same time releasing cord Z and allowing weight X to pull vent pipe damper Y open, thus providing instant outlet for the smoke and flame, and closing all openings. The same would be true of a fire starting at the film box. Harness rings are preferable to pulleys in view of the liability of a cord to catch in a pulley.

Such a set of shutters could not be raised by pulling on the master cord at I. It would require two men to open them, one pulling on master cord between B and E while the other hooked the ring on bolt I. Also the shutters could be raised one at a time, blocked up and the ring attached at I, after which blocks could be removed. However, the shutters ordinarily have to be raised but once each day. The point is: shutters properly fitted and thus suspended *will work when needed.*

But all this (fireproof walls and shutters) is of slight value unless a third element be introduced. The smoke and flame must escape. They must be carried away outside the building. As has been said, film makes lots of smoke in burning. The smoke is dense, black and pungent. Also there is much gas and flame. To allow egress for all this a vent-pipe of ample proportions must be installed. This pipe must be of size to carry off the smoke, gas and flame from the burning film, or it fails of its main purpose. In this connection it must be remembered that burning film makes exactly as much smoke, flame and gas in a small room as in a large one, therefore size of room has nothing whatever to do with necessary size of vent-pipe.

Vent Pipe.—This pipe must be of metal and be thoroughly insulated from all woodwork throughout its entire length, since it is likely to get red hot in case of a film fire, and it must lead as directly as possible to the outer air. *It should have an area of not less than two square feet,* and even larger is better.

An operating room with fireproof walls, equipped with wall shutters, as described, and a vent pipe, as indicated, is nothing more or less than a stove, so far as any fire which might occur within it be concerned. The draft comes in through the crevices around the shutters and door, up and out through the vent pipe. You could burn reels of film in such a room and the audience absolutely never would know there was a fire.

Such a vent pipe would render the operating room too cold in winter; also it would cause too much draft in summer, if wide open. It should therefore be equipped with a metal damper, *weighted so as to remain normally wide open. It should only be allowed to be closed, or partly closed by means of a cord, attached to the master cord, so that the instant the master cord be slacked the vent damper would fall open.* This is illustrated in Fig. 28.

If the theater is one story the vent pipe can be run from the center of the operating room ceiling directly through the roof, being capped with a suitable hood, of course. If there are rooms above it must be run in some other manner, but the value of such a pipe is so great that it should be run in as direct a manner as possible, even at the expense of considerable sacrifice. *No operating room is truly fireproof without a vent pipe having an area of not less than two square feet.* A small vent pipe with a fan therein will not do, since there can be no assurance that the fan will be running when most needed. I have dwelt on these things (walls, shutters and vent pipe), because I regard them as of paramount importance. I would like to see a heavy penalty provided for the managers—not operators, but *managers*—for failure of wall shutters, any one or all of them, to work perfectly at any time when tested by an inspector. I would like to see license refused to any theater lacking an operating room vent pipe substantially as hereinbefore described, always remembering that a pipe of less than two square feet area is *not* a vent pipe at all, but a mere ineffective imitation of one.

LOCATION OF THE OPERATING ROOM

This is a matter deserving the most careful consideration. Its location should be finally determined only after carefully examining all of the many points involved.

The ideal location is seldom possible, since it presumes the lens to be seventy-five or more feet from the screen, and precisely in line, up, down and sidewise with its center. This condition is seldom possible in a theater with balconies, though in some of the storeroom shows it is very nearly approached.

Let us consider the items in order. First the matter of distance:

(a) Provided the air be reasonably clear, there is no perceptible loss of light by reason of a moderately long throw. The common belief that more light is required, hence high amperage at the arc, to produce an equal curtain brilliancy with a picture of given size at 100 feet than at 50, is wrong. It is not founded on fact. I assert, and I believe, the majority of operators who have had wide experience, will agree with me, that as good, or even a better picture of given size, say 15 feet wide, can be projected with a given number of amperes at 100 feet than at 50 feet. This is by reason of the longer focal length lens being sufficiently superior, from an optical standpoint, to more than counterbalance any slight loss in light by reason of the longer throw. The shorter the throw, for a given picture width, the greater must be the lens curvature, and the greater the lens curvature, the greater the liability to spherical aberration and other faults.

(b) If the screen is located very much lower than the machine, there will be frame distortion producing an inverted keystone effect; this by reason of the fact that the top of the screen is closer to the lens than its bottom. The rays have to travel further to reach the bottom of the screen than to reach its top. As the rays travel they are constantly spreading out. Naturally they will spread further in traveling the longer distance to the bottom of the screen than the shorter distance to its top; hence the lower portion of the picture will be wider than its top, and the feet of the characters will be enlarged. When the machine sets above, or to one side of the screen, the further away it is located the less will be the angle between the light ray and screen; hence the less of the keystone effect will be present, as we see at H, Fig. 134.

(c) Where two machines are used it naturally follows that both cannot be placed laterally central with the screen. One or both, usually both, will set a little to one side of the center of the screen. This has a tendency to produce an out-of-focus effect on one side of the picture. The longer the throw the less of this tendency there will be. Under seventy-five feet the effect is frequently noticeable, and under fifty it usually shows badly. It can be partially remedied by a careful selection of lenses or the stopping down of the lens slightly by a paper ring or diaphragm.

(d) The shorter the throw the shorter the focal length of lens required to project a picture of given size. Very short focal length lenses are notoriously bad. They seldom give sharp definition. Under 3½ inches equivalent focus there is usually more or less trouble in securing sharp definition. A large picture and short throw means a very "short" lens. (See chapter on Lenses).

Experience has taught us that from seventy-five to one hundred feet is an ideal distance to project motion pictures; that under fifty feet is a very poor proposition, unless the picture be quite small; also that if the machine be solidly anchored there is no objection to exceeding one hundred feet by a considerable distance.

We may, therefore, sum up as follows: Between seventy-five and one hundred feet, or even one hundred and twenty-five feet, there is slight choice, except that the longer distance is the better if the machine is to one side of, or considerably higher than the screen; that unless the picture be quite large there is no serious objection to a throw as short as fifty feet, provided the machine be central with the screen sidewise, and not much above it, but that less than fifty feet throw is undesirable, except for a very small picture, say under ten feet wide.

But another equation enters into the calculation; one not very generally understood and to which altogether too little attention is paid.

To receive a perfectly true impression of the projected picture one must be at the exact optical center of the projection, which is, of course, impossible, since that means the center of the light ray. It is only at that point that absolutely no distortion appears.

Fortunately, the distortion is slight; in fact, scarcely perceptible, if one be within reasonable distance of the optical center of projection. No doubt the reader has noted the distortion due to an extreme side view of the picture. The actors and objects in the picture appear very tall and thin. What is not generally reckoned, however, is that this effect begins the instant the eye departs from the exact center of the light ray. Still, it is so slight as to be negligible until the angle with the projection becomes very considerable. It is a fact that the operator himself is the only one who ordinarily sees the picture exactly perfect.

Not only is the foregoing true of a side view, but it is also, in less noticeable measure, true of angle in height. Where the machine is located in a high gallery the picture, as seen from the orchestra is distorted to a considerable extent though the audience does not usually realize that fact. The next time you are in a theater in which the projector is located in a high gallery, look at the picture from the orchestra and then view it from the gallery in which the machine is located. You will note a surprising difference. From this we gather two facts, viz: (a) If the house is wide, as in a large theater, the screen should be located at the extreme rear of the stage, unless by so doing the view of the screen from side seats is cut off. At any rate place the curtain as far back as is practical, thus reducing the angle of view as much as possible to that portion of the audience at the side of the house. (b) That the operating room should be located, where possible, in such manner that the light ray will just clear the heads of those in the highest priced seats, though it may be just under them if the high price seats be in a balcony. If all seats are the same price the location, as to height, should be as nearly as possible in center of the audience (up and down). Thus as nearly as practical a uniform angle of view will be provided for the entire audience, and the distortion will be reduced to a minimum.

VENTILATION OF THE OPERATING ROOM

An important matter. In summer the operator is compelled to sit for hours beside a lamphouse which is, in effect, nothing more or less than a very hot stove. The vent pipe, before described, will provide plenty of air, but it must be remembered that since the operating room is usually located near the ceiling, and since hot air rises, it follows that the air sucked in will not only be the very warmest in the house, but will also be vitiated and rendered foul by the exhalations of the audience. It is unfit for use by a human being. Moreover, if it is sucked in entirely through the lens and observation ports, it creates an unpleasantly strong draft directly in the operator's face.

This may be partially stopped and much fresh air introduced by providing inlet openings at the bottom of the room, the same connected with the outer air at any convenient point. Sufficient fresh air will thus be brought in to greatly reduce the port hole draft, as well as to freshen and render reasonably wholesome the air of the operating room. These openings should, however, be provided with fire shutters, arranged to close automatically in case of fire. The heat may be largely reduced by connecting ordinary six-inch stove pipe with the vent pipe, bringing same down over the lamphouse, terminating it in a suitable hood, like that on a French cooking range. Also this pipe may be three or four inches, instead of six, and connect *directly* with top of lamphouse, being provided with a swing joint if the lamphouse must shove over to accommodate a stereopticon lens. The latter arrangement will operate to reduce condenser breakage also.

Such things are not costly to install. Once put in they last indefinitely. They render the operating room far more healthful and comfortable; hence they put the operator in better position to do his best work. The Massachusett's law contains the following provision concerning the ventilation of operating rooms:

> Operating rooms to be provided with an inlet in each of the four sides, said inlets to be 15 inches long and 3 inches high, the lower side of the same not to be more than 2½ inches above floor level. Said inlets to be covered on the inside by a wire net of not greater than ¼-inch mesh; netting to be firmly secured to the asbestos board by means of iron strips and screws. In addition to the above, there shall be an inlet in the middle of the bottom of the operating room, if possible; otherwise in the side or rear of the operating room, not over 2½ inches from the floor. Said opening to be not less than 160 square inches area for a No. 1 operating room, 200 square inches area for a No. 2 operating room, and 280 square inches area for a No. 3 operating room; connected with the outside air through a galvanized iron pipe with a pitch from the operating room downward to the outside wall of the building. The opening to be covered with a hood, so arranged as to keep out the storm, and the entrance to the operating room to be covered with a heavy grating over ½-inch heavy wire mesh, if in floor; or a ½-inch wire mesh, if in wall; and arranged with damper hinged at the bottom, and rod or chain to hold said damper in any position. Mesh and gratings to be securely fastened in place, those in the walls to be bolted on as specified for the smaller inlets.

The same law contains a provision for a vent pipe not less than 12 inches in diameter from the ceiling of the operating room to the open air, outside the building, or to a special incombustible vent flue. In a two machine operating room, this pipe must be not less than 16 inches in diameter, and in a three machine operating room, it must be not less than 18 inches in diameter. This is fairly good. The law, however, requires the installation of an electric fan in this pipe. This provision I regard as distinctly bad, for the reason that there is and can be no assurance that this fan will be in operation, or in shape to be operated at the moment a fire occurs; and if it were not in shape to operate, or were not operating, then its blades would very seriously obstruct the passage of smoke and flame through the pipe when it should be absoluely open and free. I take the position that the vent pipe should be absolutely open and free, and should be of such size as to carry off all smoke and flame without the aid of a fan. In this connection, let it be noted that the law quoted is doubly bad, in that it makes no provision for the closing of the lower inlet port when fire starts. The one important thing in the whole scheme of panic provision is to avoid any smoke or flame in the auditorium. With a vent flue of ample size, leading to the open air and with everything closed, including the inlet ventilating ports, then the draft would be very strongly inward around the crevices of the various shutters, and no smoke or flame escapes. With the lower inlet ports open, however, there would be such a rush of air that the upper vent pipe would very likely be congested and smoke might appear in the auditorium around the crevices of the upper shutters. The law quoted is perhaps the best there is in existence to-day, but it falls short in these very important details.

CONVENIENCES FOR THE OPERATING ROOM

The wise manager will, remembering that his box office receipts depend to a great extent on the work of the man-behind-the-gun in the operating room, provide all reasonable convenience. He will, in fact, pay as much or more attention to the comfort and convenience of his operator as he does to matters pertaining to the auditorium.

When planning an operating room it is well to include a closet, or two of them if two operators are to be employed, in which tools, supplies and clothing can be kept. This closet should be provided with a good lock. It is rather discouraging for an operator to provide himself with a costly kit of tools and be then obliged to leave them at the mercy of anyone, from the janitor to the chance visitor, to say nothing of the other operator, who perhaps has none of his own, or is not inclined to take the best of care of those belonging to others. The closet need not be large. It may be located outside the operating room. Plenty of shelves and hooks enable the operator to keep supplies and et ceteras in order. When something goes wrong, as will happen with anyone at times, and an audience is waiting, perhaps in darkness, it is well to have what is needed for the emergency repair exactly where one can lay his hand on it instantly. There is no time then to search through a miscellaneous lot of tangled wire for the thing wanted. It is no time then to hunt up a fuse, perhaps only to find it is a bad one.

By all means provide places to keep things. Then if the operator does not keep them in place and in order he is not the right sort of man to be in your operating room.

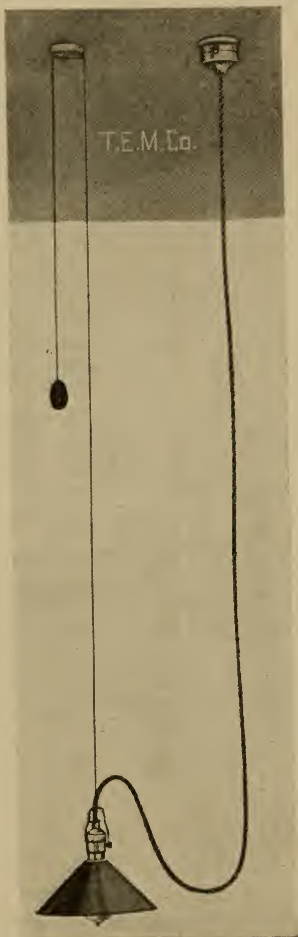
Supplies for the Operating Room.—It is poor economy, very poor indeed, to be niggardly in the matter of operating room supplies. The operator who will waste supplies simply because he has plenty, should be discharged forthwith. However, be sure he *is* wasting them before you act. Because an operator does not continue a thing in use until it is entirely worn out is not necessarily evidence that he is wasting supplies.

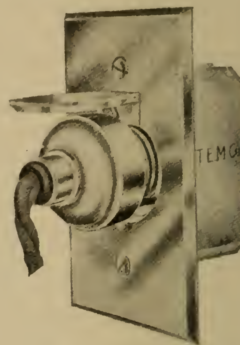
A good operator does not wait until a part breaks down entirely, thus perhaps stopping the show while repairs are made. He renews it before the break comes.

Take the matter of asbestos wire lampleads. Nine operators out of every ten use them entirely too long. It is a most excellent plan to cut off these wires outside the lamphouse after about forty-eight (48) actual hours' use, if using more than 40 amperes of current, or after a run of 60 hours if using 30 to 40 amperes, or after 100 hours' run if using less than 30 amperes. Cutting off these wires is not waste. It is true economy, since they offer high resistance if run too long, thus injuring the light and eating up far more than the cost of the wire in wasted energy, all of which waste is registered on your meter, and from which you get no benefit.

Nine times in ten intermittent sprockets are run entirely too long. This is hard on the films and will probably produce vibration of the picture on the screen. I name these examples to show that it does not pay to be too economical of supplies in the operating room; also that lack of knowledge often causes the manager to practice false economy by compelling the extended use of things which might far better be discarded. Managers should secure an operator in whom they can have confidence, and then allow him a reasonably free hand in the matter of supplies. Many thousands of dollars are annually lost to the box offices of this country through failure of managers to grasp the importance of this point.

In the operating room, or at the instant command of the operator, should be an ample supply of carbons, wire of the various kinds used, bought in quantity instead of in yard lengths; plenty of fuses, slide cover glasses (clean, not dirty), stereopticon mats and gummed binder strips; an extra star, spindle and intermittent sprocket, assembled all ready to slip into place; extra machine bushings for intermittent sprocket shaft; condensers — in fact, everything likely to be needed.





31 A.

31 B.

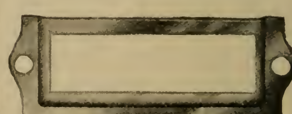


Fig. 30.

Fig. 32.

There should be a galvanized iron can, or pail, of such form as to be not easily upset, to receive hot carbon butts. This can should contain water. If the operating room has an iron-covered floor, there should, by all means, be a cork, rubber or linoleum mat, of ample size, on the operating side of every machine. Otherwise the operator may and most likely will be subjected to many unpleasant shocks. The writer would refuse to operate on an ironclad floor without insulating mats. This does not necessarily hold true, however, if the machine and lamphouse be thoroughly and effectively grounded.

Interior Operating Room Walls.—The less light in the operating room, while the picture is being projected, the better view the operator will have of it. It is almost impossible to detect slight discolorations of light on the screen if there be much light in the operating room. The walls should be painted a dark color. The writer prefers dead black (without gloss), but a dark green is excellent, and is preferred by many. The shade should be quite dark, however.

Operating Room Lights.—There should be plenty of light available in the operating room. In case of breakdown one must work very fast, and this cannot be done in semi-darkness. The location and number of lights will, of course, depend on size of the room, number of machines, et cetera.

Over each machine should be suspended one light arranged as per Fig. 30, but minus the shade and plus a wire guard. These fixtures can readily be made, or may be had complete from the Trumbull Electric Mfg. Company, Plainville, Conn. There should also be a lamp, protected by wire guard, with cord long enough to reach from its socket to any part or corner of the operating room. One never knows when a small screw will be dropped, or something else will happen requiring light in remote corners.

Fig. 31 illustrates a wall receptacle and a fixture which is most convenient for such a purpose. The plug is screwed into the receptacle and is left there. It is "alive" all the time. The lamp cord is attached to the cap portion and by lifting the lid of the fixture and shoving the cap-prongs into the receptacle there is light at the lamp instantly. It is detached merely by pulling out the cap. Such a fixture is not a necessity, but it certainly is a great convenience. The receptacle may be located in the wall at any convenient point from which the entire room may be reached by the least amount of cord.

Programme Board.—Where vaudeville is run it is necessary that the operator have the programme for the day before him in convenient form. This is also desirable where several reels are run. It is best accomplished by card holders similar to the one illustrated in Fig. 32.

These holders may readily be made by the operator from sheet metal, of any suitable size, and mounted one above the other beside one of the observation holes. Understand I do not say that such conveniences are necessary. They are not. A sheet of paper containing the desired information will answer, and answer perhaps just as well. However, such things look workmanlike. Their presence creates a good impression. They cost little, even if purchased, or they can be made practically for no cost at all except the labor.

Operator's Chair.—I have known managers who refused to allow a chair in the operating room, compelling the operator to stand up during the entire shift. Their explanation was that the operator would be more alert and attend to business better if standing. That is not true. A tired man never attends to things very well. It is a hard task to stand up for hours at a stretch. The ordinary man becomes very tired, and in proportion to his weariness his work suffers. It is good policy, not only to allow, but to provide a comfortable operating chair, or at the least a stool of proper height.

The Ammeter and Voltmeter in Operating Room.—While the theater taking current from city mains will probably find slight advantage in having a voltmeter in the operating room, it will certainly pay to have an ammeter. By this I do not mean a cheap, unreliable instrument, but a good ammeter, which can be depended upon to give a reasonable accurate reading of the current consumption. The ammeter should be placed in such position that the operator will have a full view of it at all times. There is very little question but that it will enable him to so handle his light that the saving of the price of the instrument will be effected in a comparatively short time. It is a fact that sometimes the sixteenth of an inch difference in the length of an arc will cause it to consume nearly one-fourth more current, without any additional illumination on the screen. I regard the purchase of an operating room ammeter as a most excellent investment. It should be attached to the operating room feeders at the point where they enter the operating room, so as to indicate all current used therein, and should, as I have said, be located in plain view of the operator. The method of connecting in an ammeter or voltmeter is clearly shown in Fig. 33. They may be connected in on any circuit, at any point, as shown. The ammeter, through which all current registered passes, must be actually connected into the circuit as shown, but an accurate reading of voltage may be taken merely by touching the wires of the voltmeter to the opposite wires of the circuit.

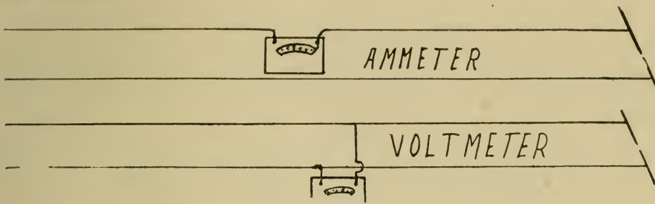


Fig. 33.

Anchoring the Machine.—If the picture is to be steady on the screen, the machine itself must be rigid. Several of the newer types of machines are supported on an iron pedestal of considerable weight. These pedestals are quite steady, provided their base be properly made and that the operating room floor

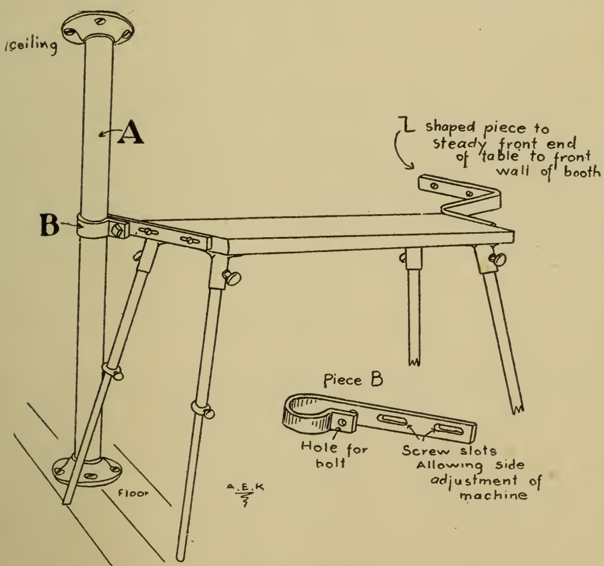


Fig. 34.

be itself solid. What is perhaps the best method of anchoring the four-leg machine tables of the type shown is illustrated in Fig. 34.

The pipe (A) is cut just long enough to stand upright and clear of the ceiling. The flanges are then put on and unscrewed until the pipe is held rigidly. Collar (B) joins pipe and back end of machine table firmly together. The rest is self-explanatory.

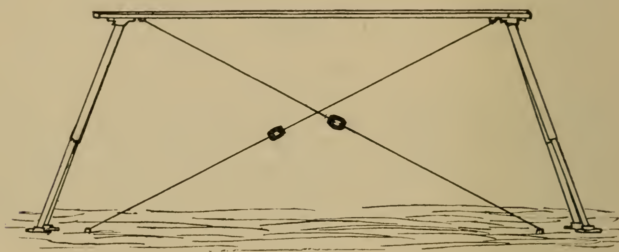


Fig. 35.

The legs of the type of table shown in Fig. 35 should always be set in iron sockets, which may be procured from the manufacturer, and the sockets screwed firmly to the floor. Before fastening sockets to the floor the legs should be spread slightly. This will hold the table firmly and allow very little vibration. Rods and turn-buckles, as shown, may also be used. The illustration is largely self-explanatory. Quarter, or three-eighths inch iron rods with turn-buckles are used, attached at either end to stout staples. The turn-buckles may be procured at almost any hardware store for a few cents. The staples should be of the kind used for padlocks, having a plate which can be screwed to the table and floor.

Announcement Slides.—All announcements should be made on the screen. It savors of amateurishness to make announcements by word of mouth, except perhaps in some special instance where the subject requires considerable elaboration, in which case a practiced speaker should do the work. Announcements may be written with pen and ink on glass, which has first been prepared by coating with a solution made by dissolving one ounce of gum arabic in one pint of water. Clean cover glasses thoroughly and dip them in this solution. Let them dry and they may then be written on with pen and ink without danger of the ink blurring. One may also coat glass with an opaque coating and write in same with any sharp pointed instrument.

What is perhaps the best scheme, however, is clear, or frosted gelatine. This may be written on with a typewriter, or with pen and ink. The gelatine written on is then bound up between cover glasses. For making such slides, however, whatever else is used, it is well to have a pen and bottle of India (draughtsman's) ink in the operating room, together with a few gum arabic coated slides, so that it is possible for the operator, in three or four seconds, to write a slide which, though crude, will be legible. These slides should be used only for emergency. They are too crude for regular use. The gelatine slides may be used for chorus slides, in event a song-slide set is minus the chorus. By the use of any of the above slides, future programmes, feature films, acts, etcetera, may be announced.

Aside from such slides there must be, of course, the regular announcement slides, such as "Five Minute Intermission," "Good Night," etcetera. These slides may now be had in metal, the letters being punched out. They cost more than the glass slides, but are practically indestructible; therefore, they are much the cheaper in the long run. In glass announcement slides some very handsome designs are now available. There should be several different slides for the same thing, for the sake of variety. Patrons get tired of looking at the same announcement slides week after week. For instance, get six different intermission slides; use one for a week and then use another for the second week, and so on. This keeps freshness on the screen, and at the end of six weeks the first intermission slide will be fresh again.

Wiring the Operating Room

LET me begin this subject with the emphatic statement that *No wire of less size than No. 6 B. & S. Gauge, should, under any circumstances, be used for any part of any projection circuit.* It is false economy, from any and every point of view, to use wires of less size than No. 6 for projection circuits. Even though you propose using only fifteen or twenty amperes at the arc, I cannot in any degree modify the above statement. Projection circuits are subject to heavy fluctuations in amperage. Parts of the circuit are subject to a considerable, and often to a very high degree of heat. This occurs at the resistance and at the arc. Copper deteriorates rapidly under the action of heat, and its carrying capacity rapidly becomes less through oxidization of the copper. It is exceedingly good, therefore, to have the wires, especially at the points subjected to heat, larger than indicated by the rating given in Table I.

All operating room wires, except asbestos covered rheostat and lamp leads, should be placed in metal conduits, one form of which, known as "B X" is flexible. This is required by law in most cities, and it is a good requirement, too.

Wires leading to the operating room must be of a size to carry the combined amperage of all lamps, when all are burning, without exceeding the Underwriters' rating. See Table I.

In this connection let it be noted that where a three-wire system is used, all three wires coming into the theater, the incandescent lamps in effect burn in series of two. Therefore only half the amperage necessary for an equal number of lamps on a 110 volt two-wire system is used. The voltage is double that of the two-wire system, so that the same wattage is consumed, but the amperage is only half. This means that the two outer wires need only contain ¼ the number of circular mills necessary for an equal number of lamp candle power on a 110 volt two-wire system. The center wire should have the same diameter as the two outer ones. This does not, however, hold good with a projection circuit, since a certain given amperage is necessary for each lamp, and the projection arcs do not burn in series with each other as do incandescent lamps.

Operating Room Cabinet or Switchboard.—Operating room feed wires should terminate in a main operating room switch which is usually located in a metal cabinet, having a door held normally closed by a spring. Here also should be located a cut-out block with fuses, same to be equal to capacity of feed wires. The usual practice is to place these fuses ahead of the main operating room switch. I see no good reason for this, however, as there is very slight chance of trouble at the switch, which is protected by fuses on the main house switchboard anyhow, or should be, and it is more convenient to install a fuse should one blow, if by pulling the main switch the fuse block is killed.

In this cabinet may also be located the various (if more than one) machine circuit fuses. It is not necessary to install switches in this cabinet for the various machine circuits, since there will be the operating switch with which to handle the arc, and any circuit may be killed, if desired, by removing the fuses. Cabinet switches are convenient, yes; but not necessary.

Fig. 36 illustrates an operating room main cabinet in which the feed wires enter from below. If they come from above the arrangement would be reversed. The various circuits are shown leaving the box at the top, except for No. 5, which is the operating room incandescent circuit. The circuits may, however, be taken out at the sides or anywhere desired. 1-1-1 are the main operating room fuses which carry all the current used in the room. They are of the link type. 2 is the main switch which kills the whole room, except the incandescent circuit. 3-3 are double cut-out blocks, of porcelain, which may, if desired, carry circuit switches in addition to plug fuses X-X-X-X-X-X-X-X. 4 is a single porcelain base cut-out block; 6-7 are projection arc circuits; 8 and 9 dissolver lamp circuits, and 10 carries the spotlight.

Where three-wire leads enter the operating room and connection is made on both sides, the lead should be balanced as much as possible, even though it is impossible to balance the projection machine arcs, since ordinarily but one will be burning at a time. However, there are times also when both will be lighted at once. If both were on one side it would unbalance the system very badly, especially if heavy amperage be used. Connect one projection lamp to each side therefore. The dissolver lamps we have balanced, thus, of course, one being hitched to either side.

In Some Cities the light company will not allow any but the two outer wires run to the operating room. This compels the use of 220 volts, which, if rheostats are used, is very wasteful. It is done to prevent the unbalancing effect of projection arcs.

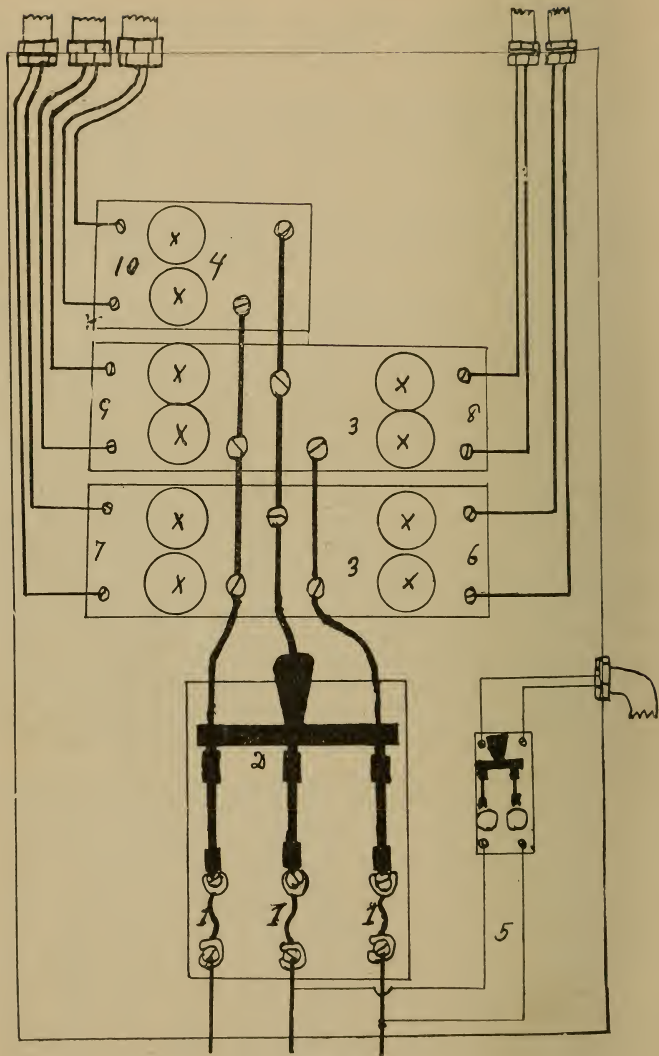


Fig. 36.

It is quite possible that this unbalancing might be very serious indeed, from the light company's point of view, in a city where there are a great number of theaters. Suppose one set of street feeders supply a dozen motion picture theaters, each having two machines connected to opposite sides of the three-wire circuit. Now suppose it so happens, as it might easily happen, that all operators chance to be using the arc connected to one side at one time. If the arcs only pull an average of 30 amperes each it would mean the unbalancing (see three-wire system, page 39, for explanation of unbalancing) of the system by 360 amperes; a very serious matter indeed, even where large generators are used. It is to avoid this that many companies refuse to allow projection arcs to be connected to the neutral of their three-wire system.

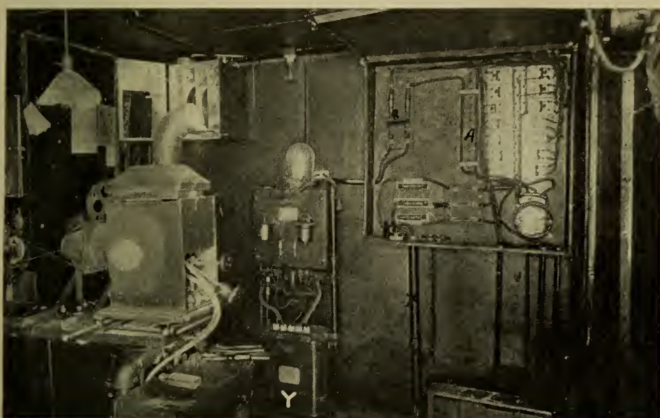


Fig. 37.

But to return to our subject of cabinets: In many operating rooms the switch cabinet is mounted on the wall directly in front of the operator. When thus mounted it, in some cases, also contains the operating switches (though this plan is not to be commended) as well as the main switch, fuses, etc. Perhaps a good purpose will be served in the best way by submitting a few views showing operating room arrangement.

View Fig. 37 illustrates a cabinet similar to the one diagrammatically illustrated in Fig. 36, except that it contains fuse blocks and service switches for the house incandescent circuits. Ap-

Fig. 38.

Fig. 39.

parently it serves as both operating room cabinet and main house switchboard. X is the conduit through which the feed wires of the three-wire system enter. A is the A. C. side of the operating circuit, which passes through an ammeter. It then enters a Mercury Arc rectifier and is transformed into D. C. At the upper right hand corner is the ventilating fan. In the upper left hand corner is a film box, the location of which should be nearer the floor where the air is cooler. Y is a Mercury Arc Rectifier.

In view Fig. 38, the switch cabinet is located directly in front of the operator. At the lower right hand corner is seen an opening for fresh air, and in the ceiling a real vent pipe. By "real" I mean one of ample capacity to carry off the smoke and fumes

Fig. 40.

from any film fire which might occur. It will be observed that this arrangement supplies abundant fresh air ventilation, without the draft striking the machine or operator. The lens-port shutter is apparently tied up, and that is very bad, indeed.

In Fig. 39 an arrangement somewhat similar to Fig. 38 is shown, the operating switches being located under the machine table. Note how the conduit comes up under the machines, with the outlet close to the switch; an excellent arrangement indeed. Also notice the wash basin in the lower left hand corner. The operator here is provided with adjustable stools. There is also ample length of asbestos cable lamp leads, presumably so that the ends inside the lamphouse may be cut off when they become charred, which is as it should be.

View Fig. 40, shows an unprotected marble switchboard, located in front of the machines. At the rear wall is what appears to be the main house switchboard. The floor is apparently iron-clad, but you will note the insulating mats in front of each machine. This operating room is of unusually large dimensions.

In Fig. 41 we see a most excellent operating room switchboard. It is apparently of marble or slate and carries, besides the fuses and switches, ammeter and starting boxes for the motor-generator sets seen below. Presumably the rheostats just above the starting boxes are field resistance to govern the generator amperage. If

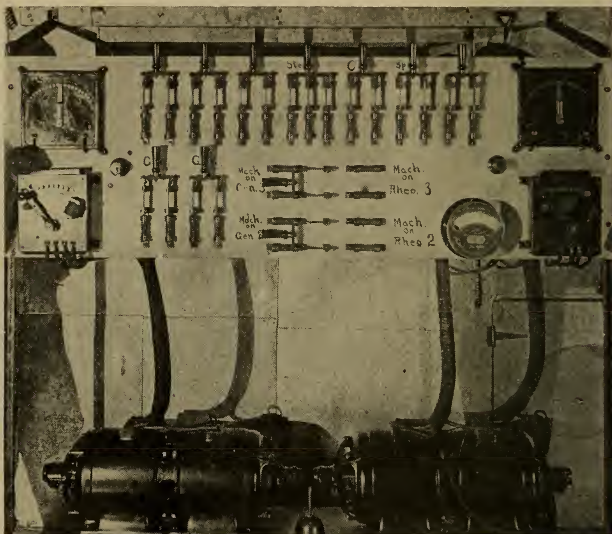


Fig. 41.

so, it would seem they might better be located within reach from operating position.

As to the method of running the various projection circuits, little need be said. It is largely dependent upon circumstances and personal preference. They may be carried up out of the cabinet, across the ceiling and down, the conduit outlet being just behind and just below the lamphouse. They may be carried to the front of the machine on the wall, or across the ceiling and down the wall to front end of the machine table and along its under edge to the rear of the lamphouse, terminating there in the usual outlet. But what is much the better plan, where practical, is to run down the wall from the cabinet, under the floor and up under each machine, as is illustrated in Fig. 39. However, the plan adopted will necessarily depend largely upon circumstances. The main thing is to make a neat, workmanlike job, which is both mechanically and electrically perfect, and have the wires and conduits out of the way as much as possible.

As a rule, city inspectors require that all switches (except those of the enclosed type) and all fuses to be enclosed in metal cabinets. For that reason I have said it should be done. However, if a switchboard of the general type of excellence shown in Fig. 40 or 41, be used, there is no real reason for it, other than the arbitrary ruling of the inspector, or the law of the department he represents. However, if link fuses be used, and I hold them to be the proper fuse for projection circuits for reasons set forth under the heading "Fuses," they should invariably be enclosed in a cabinet.

Unless local law prescribes location of operating switches the writer prefers them to be placed on the wall directly in front of the operator. This is, however, but an individual preference. Under the machine table is perhaps as well. If under the table, however, they must be of the enclosed type, i. e., covered by a sheet metal casing.

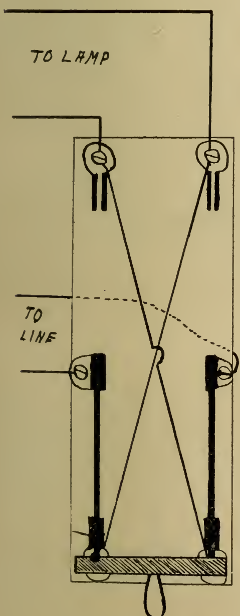


Fig. 42.

Double-Throw Switches have their purpose, but *it is never good practice to connect two machines on one double-throw switch.* This is often done; in some good houses, too. It is to be condemned, however, from several points of view. Every machine circuit should be entirely independent of every other one. The chief difficulty with connecting two projection arcs to one double-throw switch lies in the fact that when this is done but one arc can be burned at a time. This prevents burning craters on new carbons installed in one of the lamps, while the other is in operation. If a reel is running on one machine and the other projector is to be started immediately when it is finished, the light is bound to be bad until craters are burned, if fresh carbons have been installed. Connect every operating arc so that it is entirely independent of every other one. You will thus avoid much trouble and annoyance.

Where supply is taken from a small D.C. plant it sometimes happens that when dynamos are changed the polarity changes. This requires instant changing of your own wires to bring the positive to the top carbon. This may be quickly accomplished in several ways. One of the best is illustrated in Fig. 42.

Fig. 42 is self-explanatory. It will be seen that merely by throwing over the switch the polarity of the two wires leading to the lamp is changed. The cross wires should be protected by flexible insulating tubing, in addition to their own insulation. Such a switch, if enclosed in a metal cabinet, could be utilized as an operating switch by capping the contacts not in use with some kind of a covering to prevent mistakes, by closing the switch the wrong way.

CONNECTING TO TWO SOURCES OF SUPPLY

For various reasons it frequently is desirable to make connections to two separate sources of electrical supply. One may have one's own light plant, but wish, in case of accident, to be

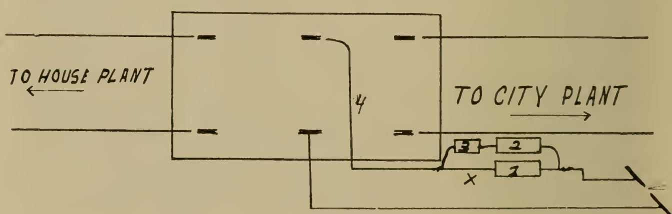


Fig. 43.

able to instantly connect to the wires of the city light plant. This may be readily done, but the conditions may be very different in different cases. Suppose we have a house plant delivering direct current at 110 volts, while the city plant produces alternating current at 110 volts. Both systems two-wire. The problem is then simple.

We install a double-pole, double-throw switch as shown in Fig. 43. For the sake of convenience we have omitted the switch handle and bars in this sketch. The house plant being D.C. we shall not need nearly so much amperage from it as would be necessary for good curtain illumination with the city plant A.C. We therefore install two rheostats, 1 and 2. The lower one, 1, is to be used with the D.C. house plant. 3 is a single-pole, single-throw knife switch, which is opened when house plant D.C. is in use, so as to only use rheostat 1. When we throw over to the A.C. plant, however, we close switch 3, thus cutting rheostat 2 in multiple with rheostat 1. Rheostat 2 should have capacity sufficient to build the combined amperage of the two up to that necessary to good curtain illumination. Suppose we use 35 amperes D.C. We will then, in order to secure anything like the same curtain brilliancy, have to have rheostat 2 of capacity to build the amperage up to 60. But we must remember that, owing to the shorter A.C. arc, hence the less arc resistance, rheostat 1 will deliver somewhat more current on equal voltage A.C. than it will on D.C. We shall probably not be far out of the way if we have rheostat 2 of capacity to deliver 20 amperes on A.C.

But we may, instead of this, install a transformer (Economizer, Inductor, Compensarc, etc.) in place of rheostat 2, with a single-pole, single-throw switch at X to cut-out rheostat 1 when switching to A.C. We would then when cutting in on A.C., pull switch X and close switch 3. In the latter arrangement, a single-pole, double-throw switch instead of switches X and 3 would be still better. Wire 4 should be connected to the center pole of the

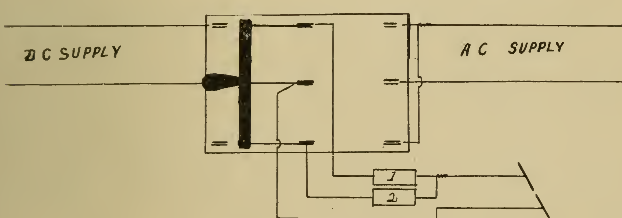


Fig. 44.

switch with the lamp connected to one end contact through the rheostat end to the other end through transformer. Merely throwing the switch would then change from rheostat to transformer and vice versa.

Please understand that there are other switch arrangements possible. Such things may be done in many ways. Those suggested merely illustrate two ways of doing it. Another, and better way of accomplishing this result is by means of a triple-pole, double-throw switch as in Fig. 44.

A careful tracing out of the connections in Fig. 44 will show that when the switch is thrown to the A.C. supply side the two rheostats are in multiple, while when the D.C. side is in use only rheostat No. 1 is working. In fact, there are quite a number of ways in which such a connection may be made. Should the supply voltage be higher on one system than the other, a high voltage rheostat could be substituted for rheostat No. 1, Fig. 44, and another connected as shown, in multiple, of such capacity that it would bring the amperage up to normal when on the lower voltage.

When Rheostats Are Used for resistance they should either be located outside the operating room or else have a hood over them with a pipe leading therefrom to the vent pipe, or to the open air. They generate a great deal of heat and in summer their presence in the operating room, unless as above set forth, adds very largely to the operators' discomfort. For details as to their installation see "Resistance."

Tools are an important item to the operator. I have met managers who would allow no tools in the operating-room, claiming the operator caused more trouble with them than he remedied. The "Operator" was continually "monkeying" with things. Naturally, through lack of knowledge, he did far more damage than he did good.

The trouble has been, as I have repeatedly pointed out, that the low salaries offered have failed to attract any large percentage of men with mechanical ability, knowledge and brains, to the profession of operating. We have had instead, and still to a considerable extent have in the operating-room, men and boys of such ability as may naturally be expected where a laborer's wage, or less, is offered. The man of expert knowledge cannot ordinarily be expected to be had for such remuneration. There are exceptions, I grant; also in some cities salaries have risen to a point where men of ability are attracted.

Then, too, another equation enters. The amazingly rapid rise of the business has been far in advance of available knowledge. Even the best men have been compelled to acquire knowledge largely through the slow school of experience. Coupling this fact with low salaries it is astonishing that we have advanced as fast in projection as we have. However, the knowledge is in considerable degree available now, and the operator has small excuse for its lack. We hope for better things in the future.

But to return to our subject. A good rule to follow in the operating room is: if a thing is working well, let it alone. The man who lacks ability to use tools intelligently has no proper place in an operating room. He has no more business there than has a bull in a china shop. The operator should own his own tools, except for such things as a bench vise, a hand drill and gasoline blow torch. These are properly a part of the regular house equipment. He ought to have a fairly complete kit. Remember in buying tools that the best is none too good. Cheap tools are usually a delusion and a snare. It pays to get the best, except perhaps screw-drivers. These, save the one for small screws, may be had at a ten-cent store of good enough grade, provided they be carefully re-ground. Grinding a screw-driver is an important item. One with a dull, rounded point will do much damage in scarring up screws and spoiling their slots. The following kit contains nothing which will not be of use. It may be added to at will:

One pair "button" pliers, 8 or 10-inch; one pair 8 or 10-inch lineman's side cutting pliers (I leave the matter of size open, as some prefer one and some the other); one pair 8 or 10-inch gas pliers; one large and one medium screw-driver; one screw-driver with good length of carefully tempered blade for small machine screws; one 10 or 12-inch cabinet rasp for sharpening carbons; one small riveting hammer; one claw hammer; one small cold chisel; one medium-size punch; one very small punch for star and cam pins; one small pair tinner's snips; pair blunt nose film shears (such as clerks use); one small gasoline torch for soldering wire joints; one hack-saw. With this kit you will be able to do almost any ordinary job, but you will have use for them all. In addition to the above the house manager should furnish one 8 and one 10-inch flat file, one ⅝ round file, one 8-inch "rat tail" file, a small bench vise with anvil, some soldering flux, solder wire, film cement, slide cover glass, mats and binders and wire of various sizes likely to be needed.

There is nothing in the foregoing list which will not be of use and many men will want more. Tools should by all means be neatly arranged on the wall, the screw-drivers and pliers within easy reach from operating position. Don't get into the habit of laying screw-drivers and pliers on the machine table. They are always more or less in the way and anyhow it looks unworkmanlike. The metal clamps used for fastening conduit and pipes to the wall are excellent for holding screw-drivers and all tools except punches. They are cheap and may be had in varying sizes.

None but the slovenly workman will leave his tools lying around. Have a place for every tool and *keep every tool in its exact place*. Not sometimes, but all the time, except when in actual use. It takes a second to replace a tool when through with it. It may take minutes to find it when wanted in a hurry, if you have formed the habit of dropping your tools wherever used last, When anything happens tools are wanted quickly. There is no time then for an excited search after a plier or screw-driver which you had "just a minute ago."

The audience is waiting, perhaps in darkness, while you spend more time looking for things you should be able to lay your hand on instantly, than is required to make the repair, when your search for tools and material is ended. Very few operating-rooms contain anything like an adequate kit of tools and few of even the few which have such a kit have them hung up in orderly fashion. Slovenly methods mean wasted energy, aggravation and time lost, usually just when seconds are precious.

The house should provide, in or near the operating room, a small but solid work-bench, equipped with a substantial vise. A good work-bench cannot be constructed from one-inch lumber. Use two-inch planking. The house should also provide a good gasoline blow-torch for soldering wire joints, etc.

GROUNDING AND TESTING FOR GROUNDS

There is no particular object in having the operating room itself grounded, but the iron of the machine, or the lamphouse should always be grounded to the metal of the operating room. The reason of this is that, particularly with the new types of all-metal machines, should your machine be insulated from the metal of the operating room and become heavily grounded, and should you by accident form a connection between the machine and the metal of the room, with one side of a film reel, there might be a heavy spark which might set the film on fire. For this reason see to it that the metal in the operating room and the metal in the lamphouse and machine have electrical connection.

Testing for grounds is a simple operation and the most practical plan for the operator is to use a test lamp such as is illustrated in Fig. 9. It doesn't particularly matter what c.p. the lamp is since even though the lamp does not light, you will get a spark at the instant of breaking contact if there is a ground. There should be a permanent known ground in the operating room. The best plan is to solder a copper wire to a water or a drain pipe at any convenient point, and carry one end of it into the operating room, locating the same in a convenient position. You can then test for ground by touching one end of the test lamp wire to the lamp or lamps, and the other to the ground wire. Many an operator has tested for ground and been fooled because the metal he supposed was grounded, in reality was not grounded—hence his test was of no value. Of course, if the metal of the operating room is grounded and you positively know it is, then you will need to have the permanent ground described,

Resistance

RESISTANCE is a subject with which the operator should be thoroughly familiar. He should understand exactly what it is and how it acts. He must know exactly what happens in his rheostat, and precisely why it happens, if he is to work intelligently.

In dealing with resistance it must be clearly understood that resistance, in the true sense, is that quality of an electrical conductor which sets up opposition to the flow of current, and manifests itself in the form of heat; therefore anything which is, in the true sense, a resistance device must consume voltage by reason of the aforesaid fact, and produce heat in the proportion of the voltage consumed. It therefore follows that transformers and choke coils are not and can not, strictly speaking, be classed as resistance devices. I speak of this for the reason that many electricians class rheostats, transformers, choke coils, etc., under the general heading "Resistance Devices."

Of course, in a way, a choke coil is a resistance device. Rightly considered, however, it is not, since the voltage is lowered without appreciable dissipation of energy in the form of heat, the latter being a peculiarity of resistance.

As has been stated, the positive and negative wires of an electric circuit have an affinity for each other, which is measured in voltage and corresponds to pressure in a steam boiler or water in a water main. The current seeks constantly to escape from the positive to the negative wire, and if those wires be brought into direct contact with each other, there will be a sudden flash, — the fuses have blown. This is by reason of the unrestrained rush of current from one wire to the other. Yet, as all doubtless know, it is necessary that the two wires be connected with each other, and that current shall pass from one to the other, if any work is done—any light produced, or any motors driven.

You will readily understand that if you placed an open pipe on a steam boiler, you could not raise pressure. Or if you raised pressure in a boiler and then opened a large pipe leading to the open air, the pressure would soon be dissipated. The steam would escape. You therefore install a valve in the pipe and only open it enough to allow of the passage of the quantity of steam needed by the engine, or whatever it is to be used for.

That is precisely what we do with the wires. We establish connection between them by means of an electrical valve called "Resistance."

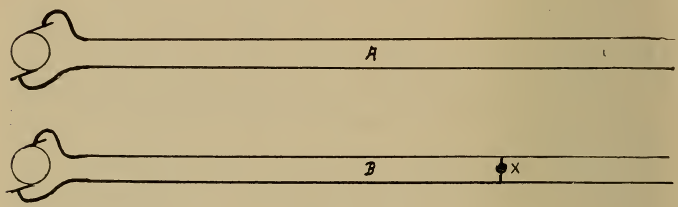


Fig. 45.

Fig. 45, A, represents a generator and two wires of an electric circuit, but there is no connection between them; therefore no current is flowing. The dynamo is running, but, in the parlance of the street, there is "nothing doing." We establish a lamp at X, B, Fig. 45, and instantly there is flow of current. The dynamo is supplying 110 volts pressure and will, being, let us suppose, a 200 ampere generator, instantly it is called upon, supply 200 amperes of current. The lamp is a 16 c.p. incandescent globe. By reference to Table II we see it "consumes" .51 of an ampere of current; that is to say, the amount of current that will pass through its filament when it is burning at candle-power. The filament forms a direct connection between the positive and negative wires. Why does no more than .51 of an ampere flow through the lamp? Why is there not a rush of current the same as when you bring the two raw wires of the circuit together? The answer is easy if the reader has studied resistance elsewhere in this book. We have been told that electric current meets resistance in flowing through a wire, just as water does in flowing through a pipe.

We have learned that different substances offer varying opposition to the passage of current; some, such as glass, rubber, porcelain, etc., having such high resistance that they are, to all intents and purposes, non-conductors—that is to say, will not carry current at all. This fact is made use of in controlling the flow of current through lamps and, in a somewhat different way, through motors also.

TABLE NO. VII.—CARRYING CAPACITY OF "CLIMAX."

WITH CORRESPONDING RISE IN TEMPERATURE.

Numbers B. & S. G.	Rise in temperature, degrees Fahrenheit.									
	100°	200°	300°	400°	500°	600°	700°	800°	900°	1 000°
	Current in amperes.									
4	18.	24.	28.	32.	36.	39.	42.	45.	48	51.
5	15.	21.	25.	29.	32.	35.	38.	40.	42.	45.
6	13.7	18.	22.	26.	28.	30.	33.	35.	37.	39.
7	11.2	15.	19.	23.	24.	27.	30.	32.	34.	36.
8	9.7	13.5	17.	20.	22.	24.	26.	28.	30.	32.
9	8.2	12.	15.	17.	19.	21.	23.	25.	27.	29.
10	7.7	10.5	12.7	15.	16.5	18.	19.5	21.	23.	25.
11	6.7	9.	11.2	13.2	14.2	15.7	17.2	18.3	19.5	21.
12	6.	8.2	9.8	11.7	13.	14.2	15.	16.	17.	18.
13	5.2	7.2	9.	10.3	11.2	12.	13.5	14.2	15.	16.

TABLE No. VIII—RESISTANCE PER 1000 FEET OF "CLIMAX."

AT GIVEN RISE IN TEMPERATURE ABOVE 75° F.

Number B.&S.G.	Temperature, degrees Fahrenheit.									
	100°	200°	300°	400°	500°	600°	700°	800°	900°	1 000°
1	6.299	6.553	6.807	7.061	7.314	7.568	7.822	8.076	8 33	8.604
2	7.904	8.222	8.54	8.86	9.178	9.496	9.815	10.13	10.45	10.77
3	10.03	10.440	10.84	10.12	11.65	12.05	12.46	12.86	13.27	13.67
4	12.64	13.15	13.66	14.17	14.68	15.19	15.7	16.21	16.72	17.23
5	15.88	16.53	17.16	17.81	18.44	19.08	19.72	20.36	21.	21.65
6	20.05	20.86	21.66	22.47	23.28	24.09	24.9	25.7	26.51	27.32
7	25.35	26.39	27.41	28.43	29.45	30.48	31.5	32.52	33.55	34.57
8	32.12	33.41	34.7	36.	37.29	38.59	39.88	41.18	42.48	43.77
9	40.5	42.13	43.77	45 39	47.03	48.66	50.29	51 92	53.6	55 19
10	50.59	52.69	54.66	56.7	58.74	60.92	62.82	64.86	66.89	68.94

In considering resistance materials, one fact should be fixed in your mind, viz: Having a given length and size, say ten feet, of No. 8 resistance wire, the higher the voltage the more current will be forced through against the resistance of the wire, and the more amperage flowing through, the higher will be the temperature of the wire. Taking "Climax" wire as an example: We find that the temperature rises as amperage is increased in accordance with the following table:

Examining the foregoing table, taking No. 8 wire for example, we find that with 9.7 amperes flowing, the temperature of the wire will be approximately 100 degrees, Fahrenheit. With 22 amperes flowing it will be 500 degrees, and with 32 amperes, it will be 1,000 degrees.

"Climax" wire has a resistance per mill foot (see page 26, for definition of mill-foot), of 525 ohms at 75 degrees, Fahrenheit. Its temperature co-efficient is .0003 per degree, Fahrenheit. Its specific gravity is 8.137. Its resistance increases with the temperature, as is indicated by Table No. VII. Thus we see that a No. 6 Climax wire offers 20.5 ohms resistance per 1,000 feet at 100 degrees, but at 500 feet, it offers 23.28 ohms.

As to the properties of the cast-iron grid, I have no data at hand, nor do I know of any covering the above points. I should imagine they would vary considerably, according to the composition of the casting, etc. But to return to our subject.

The filament of an incandescent lamp is carefully calculated as to its composition and size. It is nothing more or less than an electrical valve of fixed capacity. It has precisely the amount of resistance necessary to prevent the voltage from forcing more than a certain given amount of current through, and, in the case of a 16 c.p., 110 volt lamp, this flow is fixed by the filament resistance at .51 of an ampere, or $110 \times .51 = 56.1$ watts of energy. If it were a 220 volt lamp the resistance of the filament would have to be much greater. If it were a 52 volt lamp it would have to be correspondingly less. But the fact remains that the resistance of the filament must be sufficient to hold back all but a certain given flow of current. It is an "electric valve," corresponding exactly to the valve in the water, or steam pipe, except that in the case of an incandescent lamp the flow cannot be changed, except by increasing or decreasing the voltage, in which case the lamp will burn above or below its candle-power. The valve is set and locked. Broadly speaking, this is the idea, but there are different kinds of "valves," and the subject is one requiring considerable study to be fully grasped.

Table No. IX shows what the manufacturers of climax wire consider a safe load for the various sizes.

On page 25 we see that different metal offers varying resistance, and in Table VII we see that temperature also plays a considerable part in the matter. One of the first things to understand is the fact that resistance does not consume amperage. It consumes pressure. But this must be qualified by saying that when voltage is reduced by resistance there will be less amperage: thus, if there be a drop in voltage by reason, for instance, of the excessive resistance of a long line, there will be less amperage passed through the lamps, hence they will not burn to candlepower. This is not because amperage has been consumed, but for the reason that, as has been said, the lamp filament resistance is a fixed quantity, and the reduced pressure is not great enough to force through the resistance of the filament the necessary amperage to bring the lamp to candlepower. The amperage is there, ready to be used, but there is not sufficient voltage to force it through.

TABLE IX.

Size B. & S.	Amperes.	Size B. & S.	Amperes.
4	39	11	15.7
5	35	12	14
6	30	13	12
7	27	14	10
8	24	15	9
9	21	16	8
10	18		

We will take the projection arc lamp for example: Suppose we establish an arc lamp circuit, as shown at A, Fig. 46, the voltage being 110.

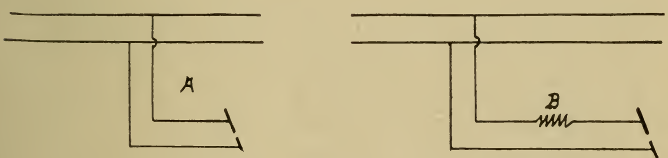


Fig. 46.

It requires slight electrical knowledge indeed to see that when we bring the carbons into contact with each other to "strike an arc," there will be a dead short circuit established, just as though the wires themselves had been brought together. This would, of course, not do at all, if the line voltage were materially in excess of the arc voltage. If we could strike the arc at all, under these conditions, working on 110 volt pressure, and get the carbons separated, we could maintain it, after a fashion, for a time, since the air gap between the carbons, which the current must jump, can itself be made to offer high resistance by increasing its length. The longer the space between the carbon tips the greater the resistance of the air-gap.

However, in practice, we cannot carry a very long arc and secure good projection light. Too long an arc produces just as poor projection light as does one too short. To get the amperage down, under the above condition, to reasonable limits, the arc would have to be very long indeed. With 220 volts we could not handle it at all. In any event such a proposition is entirely impractical, even with 110 volt current. The D. C. projection arc of proper length for best results, offers resistance sufficient to consume from 45 to 53 volts, averaging about 48, in forcing the current across the air-gap. Since the voltage at the arc must not exceed the figures named, it becomes necessary to insert in the circuit sufficient resistance as at B, Fig. 46, to reduce it to that pressure; in other words, there must be enough resistance added to consume the surplus voltage.

This could be done by using copper wire, but it would require such great length as to be entirely impractical by reason of its cost. By reference to the formula on page 19, you will see that it is necessary to have a certain definite number of ohms resistance to give a certain number of amperes under a given pressure. Now suppose we were to use 40 amperes at the arc, taking 48 as the arc voltage; that is, assuming it will require 48 volts to force 40 amperes across the air-gap between the carbon tips with the arc length best suited to projection. We will have that amount of the pressure (48 volts) consumed in the arc itself, and must therefore arrange to consume $110 - 48 = 62$ volts otherwise, since the pressure must all be consumed, or used up. How much resistance must we have to do this? Referring again to the formula, page 19, we see that voltage divided by amperes gives ohms. We have 48 volts accounted for in the arc resistance, therefore we subtract that from the line voltage and have $110 - 48 = 62$ volts, as the pressure to be consumed. Dividing 62 by 40 (voltage by amperes = ohms), we have 1 11-20 ohms as the resistance necessary, in addition to that of the arc itself. How can we get this?

Certain metals, notably German silver, offer high and fairly constant resistance. German silver was for a long time the metal used for resistance purposes, but it is costly; also it has other faults. It has been discovered that nickel steel wire, made of the same metal as is used by the Government for warship armor plate, is excellent for resistance purposes, and wire made from that kind of material is now the standard for rheostat coils. We therefore take such wire, of proper size, and of sufficient length to offer 1 11-20 ohms resistance, and insert it in the circuit. We then find we have, in the arc and the resistance wire, a combined resistance of 2¾ ohms, which allows $(110 \div 2\frac{3}{4}) = 40$ amperes, to flow through the arc.

In practice, to save space, this wire is wound into coils as per Fig. 47. These coils are fixed in an iron frame, from which they are thoroughly insulated, and each coil is joined to its neighbor, so that, in effect, the coils form one long piece of wire. *Thus we have what is termed a rheostat.* This rheostat we place in the projection lamp circuit, as shown at B, Fig. 46, and we may now bring the carbons together and strike an arc that will have a 40 ampere flow. If we wanted less amperage we would use more resistance wire. If greater amperage were desired, less resistance would be used.

Fig. 47.

In incandescent lamps the resistance is fixed and cannot be changed. This is not necessarily the case with the rheostat. Its resistance depends, as has been intimated, on the size, length and temperature of the wire composing its coils, mainly, however, on its temperature and length, since the wire must in any event be large enough in diameter to carry the current being used at the arc, without excessive heating. Rheostat wire begins to show a faint red at about 900 degrees Fahrenheit in the dark. It is not advisable to use wire at as high a temperature because the Underwriters object to it, the objection being on account of fire risk. It will probably be found that the most economical temperature at which to run a wire in a moving picture rheostat is about 500 degrees Fehrenheit. This would mean that the casing containing the rheostat would probably reach a temperature of about 200 degrees Fahrenheit, and would eliminate all danger of fire risk.

In a rheostat we do not consider the heating to be "excessive" until its coils reach the temperature above indicated. This is by reason of the fact that heat is the inevitable after-effect of resistance. That is what resistance does. It causes, or produces heat. However, it is a fact that the life of the resistance will be greatly prolonged if the rheostat be so designed that the temperature of its coils will not exceed 500 degrees Fahrenheit.

As has been explained, the rheostat uses up all the voltage in excess of that at the arc, which latter is from 30 to 35 with A. C., and 45 to 55 with D. C., averaging probably 34 and 48 for the two currents. With 110 volt line pressure, direct current, the rheostat therefore consumes about 62 volts. This energy is used in forcing the required number of amperes through the resistance, causing friction of a certain kind, and the net result of friction is heat. In other words, the excess voltage has been used up in the production of heat. We accomplish our purpose, viz: Reduce the line voltage to the arc voltage, and in the process have heat as a by-product.

It is quite possible to use ordinary iron wire for rheostatic purposes, but its use is not considered the best practice, for the following reasons: It has a very high temperature coefficient, that is, its resistance increases rapidly with the increase of temperature. When you start your arc the wire in your rheostat is cold; its resistance is low and you have an excessive rush of current. After the current is on a few minutes the wire heats up, its resistance increases, and the current passing through the arc is cut down. This means that you do not have a steady light and that a provision must be made in the rheostat for varying the amount of resistance in circuit when the wire is hot and cold.

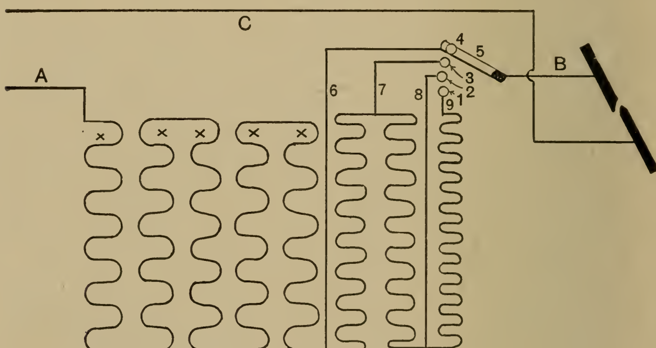


Fig. 48.

As has been said, rheostatic resistance is not a fixed quantity. It may be added to indefinitely by increasing the length of the wire, or, within certain limits, by decreasing its diameter. In practice, however, we increase its length, the diameter being fixed by the amperage requirements. We might reduce the resistance indefinitely by decreasing the length of the wire composing its coils, but this cannot, in practice, be carried beyond the point where the amperage is in excess of the carrying capacity of the wire in the coils. It must be understood that resistance wire can be overloaded, just the same as can copper wire. If the resistance of a rheostat be reduced until the wires are red hot, it is proof positive that the wire coils are carrying amperage above their capacity. The rheostat will work for a time that way, but such usage will greatly shorten the life of the coils. It is bad and very expensive practice to overload the resistance wire of your rheostat.

There are many kinds of rheostats, and they come in almost every shape and form. There are but two general classes, however, viz: Those having nominally fixed resistance and those having an arrangement for varying the resistance, usually by means of some form of sliding contact. The latter are known as "Adjustable" rheostats.

In Fig. 48 we see the adjustable rheostat principle illustrated, though somewhat crudely. A is the feed wire from one pole of the operating switch to the rheostat. B is a wire from the rheostat to the lamp, and C is the other wire of the circuit, connecting the other pole of the operating switch to the lamp. 1, 2, 3 and 4 are contacts for sliding lever, or bar 5. 6, 7, 8 and 9 are wires tapping the coils at different points and leading to contacts 1, 2, 3 and 4. It will readily be seen, even by the novice, that when lever 5 is on contact 1, the current must pass through all the coils and overcome all the resistance. It follows that the voltage, hence the amperage, is reduced as low as that amount of resistance will cut it. If lever 5 be moved to contact 2, then the current does not have to pass through the last coil, hence there is less resistance, and the amperage is increased. If lever 5 be again moved to contact 3 it is readily seen that two of the coils have been "cut out," thus still further reducing the resistance opposed to the current. If the lever 5 be still again moved to position shown on contact 4, we shall have still another coil eliminated, with consequent still further reduction of resistance and increase of amperage. This is exactly the manner in which all adjustable rheostats work, though various methods are employed for cutting in and cutting out the coils or grids. In some rheostats there is no sliding bar, but instead a series of switches. In still others the result is accomplished by disconnecting the wires and attaching them to different binding posts. However, the electrical result is the same in them all.

One very important item is, however, that when all the resistance possible has been cut out, by moving the lever, turning a knob, or making different connections by means of switches, the remaining coils or grids, X—X—X—X—X, Fig. 48, must offer sufficient resistance to keep the current within the limit of the carrying capacity of the wire of the circuit and of which the coils themselves are made. If the remaining coils or grids get red, when the lever is on 4, then the rheostat is either not well designed, or else is being used on current of higher voltage than it was built for. The rheostat will do the work even when the coils get red hot, but, as has been said, the life of the coils will be greatly shortened and they are likely to burn (fuse) in two at any time, thus stopping all current flow.

It is well to have a few extra rheostat coils at hand. Putting them in is a comparatively simple operation. They are attached in various ways by different makers, but if you examine the connections carefully you will readily see how it is done, but remember that all coils must be thoroughly insulated from the frame and cover.

Of late there has been a tendency to employ cast iron grids in place of wire coils for resistance in rheostats. However, everything said of the wire coils holds equally true of the grids. They simply take the place of the wire coils and their electrical action is precisely the same. The methods of attaching them to the rheostat frame is somewhat different, that is all. The grid is merely a cast iron wire. (See Fig. 55.) *Remember this:* No matter what shape the rheostat may be, its electrical action is precisely as set forth in the foregoing pages. The current enters one end of a series of connected coils, or iron grids, and after passing through them comes out at the other, its voltage being reduced in tne process. But, I think I hear some one inquire, if the voltage is reduced according to the amount of resistance, and the arc voltage is very nearly constant, when you cut out part of the resistance, when using an adjustable rheostat, will the pressure still be cut down to the arc voltage; if so why?

Yes. The increased flow of current, resulting from cutting out a portion of the wire, loads the resistance wire more heavily and, in this way, the matter is automatically taken care of, though there is some fluctuation of the arc voltage as the number of amperes at the arc is changed.

The whole question of resistance is a complicated one. Results depend upon so many equations that it is difficult to arrive at an exact understanding of the proposition as a whole. We know how the thing works, and what the ultimate result of the various things we may do will be, but when we are asked to enter into detailed explanation of why these results are attained, we cannot always answer with as much assurance as we might wish.

The Coils, or Grids, Are Completely and Thoroughly Insulated from the iron frame on which they are mounted and *they must so remain.* It sometimes happens that a coil will weaken after a time, particularly if overloaded, and sag. Such a coil should be renewed, as there is danger that it will (a) come into contact with one of the other coils, which would have the effect of eliminating a portion of the resistance and probably burning both coils badly at point of contact. (b) touch the casing, in which latter case the cover of casing will be charged, and the rheostat will be grounded if there is connection between whatever it stands on and the ground. The accidental cutting out of resistance, or an effective ground might also overload and heat the circuit wires, if the fuses are too large to properly protect them, as, I am sorry to say, is sometimes the case. It is best to *always set rheostats on insulating material.* Sheet asbestos will do very well. Slate, or glass, is also excellent. *Never place rheostats on an iron-covered shelf, or anything which will produce a ground, should the casing become charged from the coils.* The contacts of the coils with the casing, or whatever causes the ground, may be of so slight a nature as to be unnoticed, but if the rheostat casing is grounded there will be constant leakage, and that *leakage will be registered by the meter.*

I once took charge of an operating room in which were seven rheostats, all placed on a long iron-clad shelf. The room itself was iron lined and the iron was grounded. Strenuous complaint of excessive current bills had been made by the manager. I at once examined the rheostats and found five out of the seven slightly grounded by weak coils sagging against the casing, thus causing constant leakage. The contact between the coils and the casings was poor. Not sufficient current flowed to cause visible heating, hence the "operator" had not suspected the existence of a ground. There was some broken glass in the basement. I had some brought up and placed a piece under each leg of each rheostat, thus stopping the leak temporarily. Next day I installed new coils in place of the weak ones, and had the manager get sheet asbestos with which to cover the shelf. Current bills were immediately and very materially reduced.

If rheostats are placed within one foot of a wall containing inflammable material, there should be ⅜-inch sheet asbestos between them and the wall, with at least a half-inch air space behind the asbestos. It is always best to *locate rheostats outside the operating room.* They may be placed in the basement or in any convenient place, but *never close to anything inflammable.* They must also be thoroughly protected from direct contact with anything that will burn. If placed in a basement they should be set on an insulating shelf away from anything else, or possible contact with anything else.

Some managers locate them in the basement immediately under the ticket office floor, with a radiator grating in the floor, and they thus serve as a heater. But, wherever you locate them I cannot too strongly impress upon you the necessity for their complete insulation from the ground, and their thorough protection from anything inflammable. There are two excellent reasons for locating rheostats outside the operating room, viz: (a) They produce far too much heat in summer. (b) Danger of accidental contact between them and a film, with resultant call for the fire patrol.

If in the operating room they should be located on a shelf near the ceiling, and over them should be a hood connecting with a 6-inch metal pipe (ordinary stove pipe will do), which should be carried either to the open air, or, better still, to connect with a chimney flue, or if there is a proper vent flue in the operating room ceiling, that is to say a flue of ample size, the rheostats may be placed in such a position that the heat will pass up this flue. If installed in this manner there is not serious objection to their being inside the operating room, though I consider their installation at some outside point as being much better. Of course, under certain conditions where it is necessary to use an adjustable rheostat and change the current strength frequently, the rheostat must be located within reach of the operator.

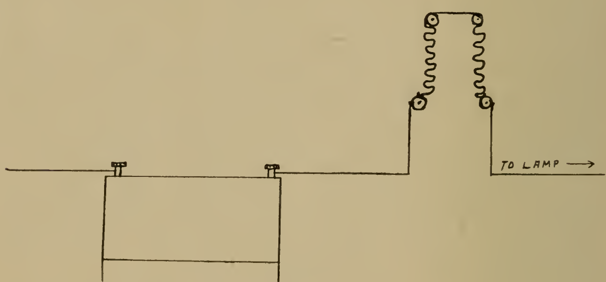


Fig. 49.

It is essential that the wire connections to the rheostat be frequently and carefully examined. Copper oxidizes under the action of the heat and, if left too long, a thin scale of oxidized copper is likely to form on the wire, or lug. This scale may be very thin and almost invisible, but it has very high resistance. Take the contacts loose once a week is my advice, and clean them thoroughly, especially if using heavy amperage.

If your rheostat is delivering too much current when all the resistance is in you may reduce it by making one or two coils out of ordinary soft iron wire, such as may be had from any hardware dealer. These coils may be supported on the wall of the room by insulating knobs, first placing against the wall at least two thicknesses of quarter-inch sheet asbestos, with an air space behind. Over them place a wire screen of about ¼-inch mesh, being very careful it does not touch the coils. Run wire from rheostat to one end of the coils and from the other end run wire to lamp, as per Fig. 49.

This same scheme may be utilized if you find your rheostat is overloaded, its coils red hot, and you wish to reduce the current. Of course, the better method is to get a rheostat better suited to your needs, but this plan will work all right, if properly done. Instead of making soft iron wire coils you can use regular rheostat coils if you have them. In case one of the coils of your rheostat should burn out and you have no other at hand, you can get around the difficulty by taking out the coil and connecting its contacts with a piece of No. 6 copper wire; that is to say, take a piece of copper wire a little longer than the length of the coil (not the wire in the coil, but the coil itself), and connect one end of it to the contact which held one end of the coil and

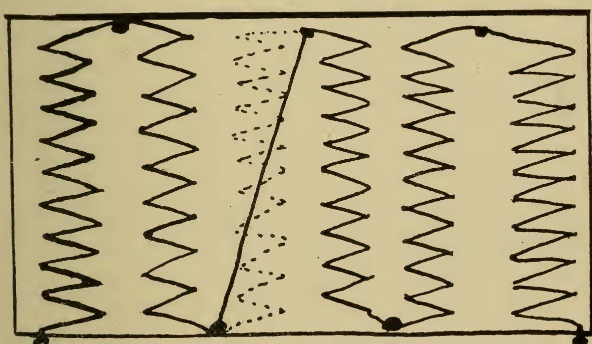


Fig. 50.

the other end to the contact which held the other end of the coil. This has the effect of cutting out the one defective coil, and will work temporarily. The idea is illustrated in Fig. 50.

You can also get soft iron, size No. 8 (diameter .128 of an inch), and make a coil for temporary use, installing it in place of the burned one. You can wind the coil on a mandrill of proper size set in a lathe, or you can do it by hand, using a piece of gas pipe, an iron bolt or even a broom handle to wind it on. Do not try to wind the wire around the pipe. Attach one end of the wire to the pipe, or whatever you use as a mandrill, and fasten the other end in a vise, rolling the mandrill while you pull on it, thus winding the wire on it in a close spiral. Stretch the coil endwise slightly when installing, so that the spirals will not touch each other. This latter is very important indeed.

SERIES AND MULTIPLE CONNECTIONS

Series and multiple connections, as applied to rheostats, is a very puzzling matter to many operators, yet it is really quite simple, once the principle involved is understood. When rheostats are connected "in series" it means that all the current must pass through both rheostats *one after the other.* Remembering that the more resistance we have the less amperage we will get, it follows that the series connection, which adds resistance, reduces the amperage.

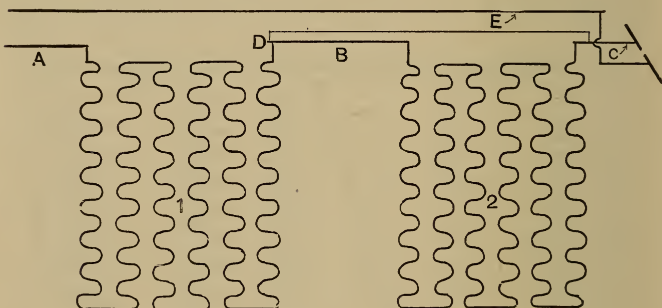


Fig. 51.

Fig. 51 is a diagrammatic representation of the wire coils of two rheostats, 1 and 2. If there were iron grids instead of iron coils it would be exactly the same problem. Wire A comes from the line. Wire B connects the coils of the two rheostats and wire C leads to the lamp. E is the other wire of the circuit. It will readily be seen that if we remove wire B and attach wire C to binding post D, as per dotted line, the current would only have to pass through the resistance of one rheostat, hence the resistance would be, so far as the rheostats are concerned, cut in half. Now suppose rheostats 1 and 2 each be of 110 volt, 25 ampere capacity, having 2 3-5 ohms resistance, and suppose we connect them, as shown in Fig. 51. You will then readily see that we now have converted the two, to all intents and purposes, into *one rheo-*

stat having double the resistance of either when used singly. Using formula on page 19, we have $(110-48) \div (2.52) = 12.5$ amperes, as the delivery of the two rheostats when connected in series. This delivery is, of course, based on a 48 volt D. C. arc and rheostats delivering 25 amperes, when working singly, in series with an arc on 110 volt direct current.

The multiple connection is a somewhat more difficult matter to make clear, though it, too, is in reality quite simple. With the series connections we have but one path for the current to follow through the resistance. With the multiple connection we have a separate path for the current through each rheostat connected into the multiple. In projection work it is seldom that more than two are used in one multiple.

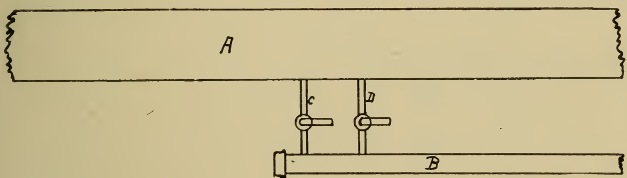


Fig. 52.

In Fig. 52, we see water supply main A, with pipe B connected to it by pipes C and D, each of which latter is supplied with a valve. Now, if we open only the valve in pipe C, we will have only the capacity of pipe C flowing into pipe B. That is quite plain. If, however, we open the valves in both pipes C and D, we will instantly have the full capacity of both pipe C and pipe D, flowing from pipe A into pipe B. This is precisely what takes place when rheostats are coupled up in multiple.

In Fig. 53, A, we see 110 volt supply wires, 1 and 2, connected to arc lamp 3, through rheostats 4 and 5, each of 25 amperes, 110 volt capacity, connected in multiple. Remembering that the voltage is constant on the line, and that lines 1 and 2 can supply up to, say 75 amperes, if necessary, is it not plain that you will get the full capacity of each rheostat, through each, or a total of 50 amperes at the arc? At B, Fig. 53, we have the same connection as is represented at A, Fig. 53, in a little different manner. We are now looking down on the top of two rheostats connected in multiple. Wire A represents pipe A, in Fig. 52. Wire B represents water pipe B, in Fig. 52, and wire C and wire D represent the two pipes C and D, in Fig. 52, while the rheostats represent the valves. Now if we should disconnect wire D and leave wire C connected, it is plain that we would have the capacity of the one rheostat at the arc. It is also plain that if we now connect wire D, as shown in Fig. 53, we shall also have the capacity of the second rheostat at the arc, and that the capacity of these two rheostats will be combined on wire B, so that if each one passes 25 amperes through, then there will be 50 amperes at the arc. The lower wire merely acts as the discharge pipe which returns the used current to the dynamo. It would seem that even the novice ought to grasp the idea readily.

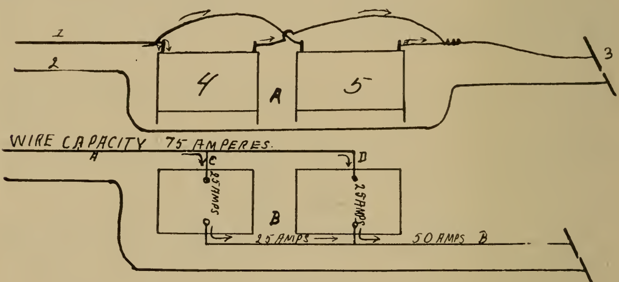


Fig. 53.

Two rheostats of different capacity can be connected either in multiple or series as logically as you can hitch a horse and a mule in double harness or tandem, as the case may be. For instance, you could hook up a 25 ampere, 110 v. rheostat and a 35 ampere 110 v. rheostat, in series or multiple, on 110 volts or less. You could connect a 25 ampere 110 volt and a 25 ampere 220 volt rheostat on 110, but you would not get 50 amperes, since the 220 volt machine, having resistance calculated to deliver 25 amperes on 220 volts, would not deliver nearly that amount on 110 volts. You could not, however, connect a 110 volt rheostat singly or in multiple on 220 volts, since it has not resistance sufficient to withstand that pressure. Its coils would get white hot immediately and it would soon burn out. You can, however, connect two 110 volt rheostats *in series* on 220 volt current (though they would be slightly overloaded), by reason of the fact that you would be in effect making one rheostat of the two, with double the resistance opposed to the current. In other words:

You may use a rheostat built for a certain voltage on that pressure, or anything less than that pressure, but you cannot use *a rheostat on a higher pressure than it is designed for, except that it be placed in series with additional resistance.*

However, a rheostat built for a certain pressure may usually be used on current not more than 10 or 15 volts in excess of that pressure. There is not such a thing as a "D. C." and an "A.C." rheostat.' Any rheostat will work on either A. C. or D. C. The rheostat that will deliver, say 30 amperes D. C., when working on 110 volts, will, however, deliver considerably more on the same pressure A. C., by means of the fact that a shorter arc is carried with A. C., hence the arc offers less resistance, and this lowers the resistance of the circuit as a whole. There is likely to be considerable noise from a rheostat when used on A. C. This is by reason of the vibration of the coils, due to rapid reversal of the current. Some rheostats are much more noisy than others, when working on A. C., and I would advise anyone purchasing rheostats to be used on A. C., to secure a guarantee that they be noiseless, in operation, or at least that the noise will not be excessive or objectionable; also that they be rheostats of a non-inductive type. By reason of the liability to excessive vibration in wire coils, the grid type of rheostat has distinct advantages over the wire coil type for use with A. C.; also they are more nearly non-inductive than the coil rheostat, hence better for A. C.

The Use of Rheostats Is Wasteful.—As has already been shown, the difference between the line and arc voltage must be consumed in the rheostat. This wasted energy is all registered in watts on the meter. Suppose the current supply be at 110 volts pressure and that we use 30 amperes through a rheostat; $110 \times 30 = 3{,}300$ watts registered by the meter. However, the arc voltage is only 48. That means we are using $48 \times 30 = 1{,}440$ watts at the lamp in the actual production of light. Therefore, we use 1,440 watts and waste $3{,}300 - 1{,}440 = 1{,}860$ watts. This is bad enough, but if the voltage be higher, say 220, the waste becomes far greater. In that case we would still be using $48 \times 30 = 1{,}440$ watts at the lamp, but the total wattage registered by the meter would be $220 \times 30 = 6{,}600$ watts. We, therefore, use 1,440 watts and waste $6{,}600 - 1{,}440 = 5{,}160$ watts in the resistance.

From what has been said the idea may have been gathered that if direct current were generated at 45 to 50 volts, or A. C. at 30 to 35 volts, it would be possible to run without any resistance at all, thus eliminating all waste. While it is possible by the use of certain types of generators, which, within themselves, automatically regulate the voltage, hence the current flow, to eliminate resistance (see D. C. Motor-Generator Sets, page 183), it is not true of current supplied by the ordinary generator. The resistance performs two functions, viz.: Regulates the amperage by regulating the voltage, and supplies a steadying resistance, or sort of a "cushion" for the arc. Without this steadying influence, or its equivalent in some other form, such as a generator of the "constant current" type, the arc would be so unstable that it could not be handled at all. Also it would not be practical to start the arc, for reasons already named.

Series of Two 110 Volt Rheostats on 220 Volts is quite common, but, while the matter is not serious, still two 110 volt rheostats in seires do not offer quite enough resistance for that pressure. They are, therefore, somewhat overloaded. In explanation: Let us suppose we have two 110 volt, 25 ampere rheostats, which we propose using, in series, on 220 volt current. Each of these rheostats was made to work in conjunction with an arc, supplying resistance to allow a 25 ampere flow under a pressure of 110 volts. The total resistance to allow a 25 ampere flow under that pressure must be $110 \div 25 = 4$ 2-5 ohms. However, as we have seen, a part of this resistance is supplied by the arc itself. That part equals a 48 volt drop, hence the rheostat supplies only $(110 - 48) \div 25 = 2\frac{1}{2}$ ohms. The rheostat is therefore one offering $2\frac{1}{2}$ ohms resistance. Two of them in series would offer 5 ohms. The arc itself offers $48 \div 25 =$ practically 2 ohms. Therefore, two such rheostats in series working with an arc would offer $5 + 2 = 7$ ohms resistance. Seven ohms resistance opposed to 220 volts would allow $220 \div 7 = 31$ 3-7 amperes to flow, which is 6 3-7 amperes in excess of the current the rheostat is supposed to supply, and for which its wires were calculated. Owing to the enormous waste as before set forth, it does not pay to use rheostatic resistance, particularly on the higher pressure, where it can be avoided (see Transformers, page 144, Mercury Arc Rectifier, page 171, Motor-Generator Sets, page 183, and D. C. Economizers, page 183). Rheostats come in many forms, shapes and sizes, but, as has been already stated, the electrical action is the same in all of them. Some are better than others because they are mechanically better made and have better insulation. You may connect a coil rheostat and a grid rheostat together in multiple, so long as they be made for the same voltage, and further provided that that voltage be equal to the pressure of the lines they are to work on. You may connect two rheostats of different capacity in multiple with each other. You may connect two rheostats, one round and one square, one adjustable and the other non-adjustable, say one a ten ampere grid and the other a 40 ampere coil, in multiple, provided each have sufficient resistance to work singly on the voltage of the line it is proposed to connect them to, and further, provided the circuit wires are large enough to carry their combined capacity. You may use a 220 volt rheostat on 110 volt lines, though the amperage delivered will be small, but you cannot use a 110 volt rheostat on 220.

You may use two rheostats of different type, as a coil and a grid, of different capacity, adjustable and non-adjustable in series. You may even use two rheostats of different voltage capacity in series, provided the total resistance be equal to that required for the line pressure. For example, we see, in Fig. 54, an Edison adjustable, grid rheostat (part of casing removed to show grids) connected in multiple with Power's (on the right) non-adjustable coil rheostat, both made to work on 110 volts.

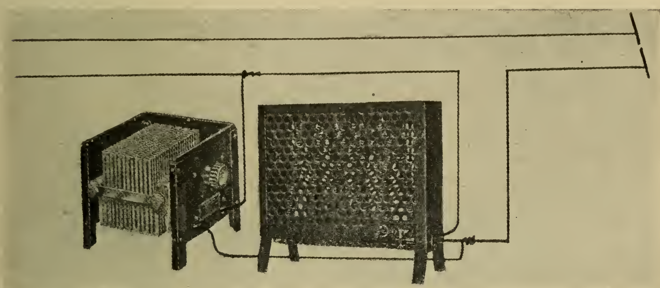


Fig. 54.

Power's is a 25 ampere, 110 volt, and the Edison is a 25 to 40 ampere, 110 volt rheostat. Therefore, we will get 25 amperes through one and from 25 to 40 through the other, according to how the adjustment knob is turned. We will have a total current of from $25 + 25 = 50$, to $25 + 40 = 65$ amperes at the arc, with this combination. With the same two connected in series on D. C. we would get from 12 to 15½ amperes. It is figured as follows: Power's is a 25 ampere 110 volt instrument, therefore has $(110 - 48 \div 25) = 2\frac{1}{2}$ ohms resistance. The Edison, when working at 25 amperes must have the same resistance, hence a total of 2 plus 2 ohms is had when they are opposed to the current in series. $(110 - 48) \div 5$ will, therefore, give us the amperage delivered when the Edison is on the 25 ampere contact. This is practically 12 amperes. If the Edison is set on the 40 ampere contact, it would then have $110 - 48 \div 40 =$ practically $1\frac{1}{2}$ ohms, which added to the resistance of Power's makes ($2\frac{1}{2}$ plus $1\frac{1}{2}$) 4 ohms. We would, therefore, have $110 - 48 \div 4 =$ $15\frac{1}{2}$ amperes delivery. If the current be A. C., then we would have $110 - 35 \div 4 = 18\frac{3}{4}$ amperes, the A. C. arc voltage being approximately 35 instead of 48, as with D. C.

It should be clearly understood, however, that such figures are approximate only. Correct figures cannot be given, for the reason that the arc resistance varies with the length of the arc; also the rheostat resistance varies with (a) temperature of coils, or grids. (b) With their age. As a matter of fact the rheostat rated at 25 amperes, and which delivers that amperage when new, does not do so after it has been used a short time. The resistance of rheostat coils gradually becomes higher for a time, and then remains practically stationary until the coils finally give out entirely. When the resistance has reached the highest point it will usually be found that the "25 ampere," rheostat is actually delivering a little less than 20 amperes. After using a wire coil rheostat for a month or more you will be far more nearly correct if you subtract five or six amperes from its rated capacity, or, rather from every 25 amperes of its rated capacity. For instance: If I had a 25 ampere rheostat which had been used a month or more I would consider it as an 18 or 20 ampere capacity, instead of its rated capacity. If it were a 50 ampere rheostat I would treat it as a 40. This applies to wire resistance only. It is claimed that the resistance of cast iron remains constant, or practically so, hence if this is the fact, the foregoing would not hold good with grid rheostats.

Fig. 55.

The cast iron grid is, in effect, nothing more or less than a cast iron wire, as shown in Fig. 55, the same being one of the grids of a Power's rheostat. It is plainly seen that the electrical action is precisely the same as though a wire coil were used. Grids of rheostats put out by different makers are all exactly the same, except that each maker uses a different shape. The electrical action of all of them is identical, except that some have more induction than others when used on A. C.

Resistance Devices

FOR a better general understanding of the subject of resistance I will give a brief description of the various resistance devices put out by projecting machine manufacturers as a part of their regular machine equipment.

Power's non-adjustable, 25 ampere rheostat, "Underwriters' Model," is illustrated in Fig. 54. It needs no further explanation. It is connected as shown (leaving the other rheostat at the right in Fig. 54 out of consideration). Run a wire from main cut-out to lamp. Run the other wire to one binding post of the rheostat, and from the other rheostat binding post run a wire to the lamp.

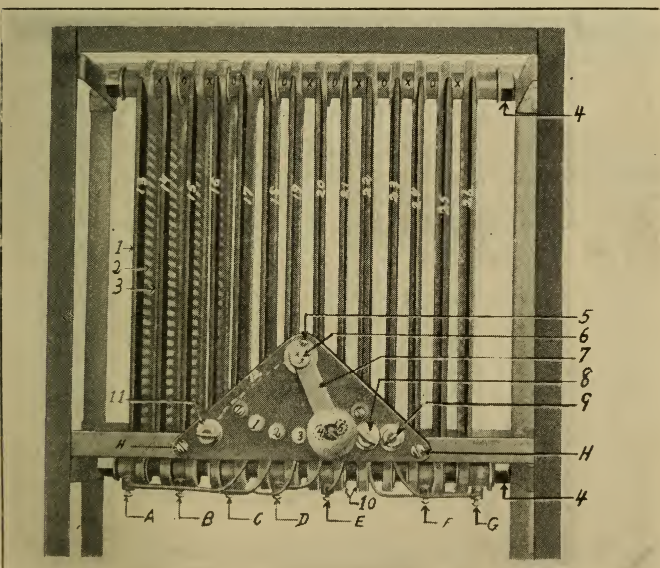


Fig. 56.

Power's Grid rheostat, shown without its case, in Fig. 56, is made for 110 and 220 volts, the 220 being the same as the 110 shown, except that instead of one bank of grids there are two placed side by side. The weight of the 220 volt rheostat is almost double that of the 110 volt device.

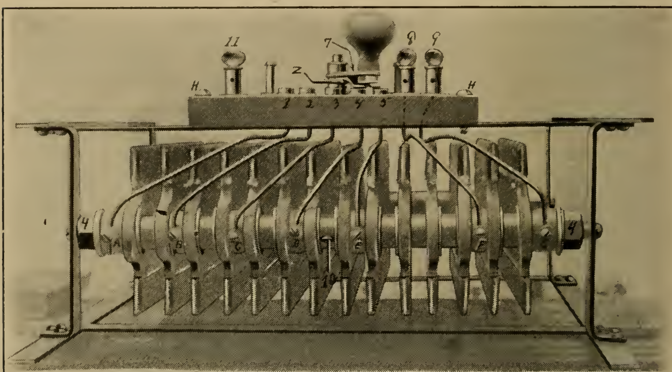


Fig. 57.

Fig. 57 shows a view of the bottom of the 110 volt grid rheostat, shown in Fig. 56. Fig. 55 shows one of its grids. The figures designating various parts on Fig. 56, and Fig. 57, are duplicated in the two pictures. The back of the contact base is illustrated in Fig. 58, being the same as that of the adjustable coil rheostat.

On tie-rod, 4—4, Fig. 56, we see, between the grids, alternately an X and an O. X represents a current carrying spacing metal washer, making direct electrical contact between two adjoining grids. O is a spacing washer which is separated from the grid by mica insulating washers, two of which are pointed out at 10, Fig. 57. These washers serve to insulate adjoining grids so that the current entering at G must pass up grid 26, across spacing washer X, down grid 25, up grid 24, down grid 23, etcetera, until it reaches a point where it can pass out at binding post eleven. Permanent binding post 11 is connected directly with adjustment handle post 6, by a wire on back of the slate contact base, same being indicated by dotted line. Binding post 9 connects directly, as we see in Fig. 57, with bottom of outer grid at G. Binding post 8 connects in like manner, as we see in Fig. 56, with lower end of the third grid at F. We run one wire from main cut-out directly through operating switch, to lamp (usually the negative in D. C., though it makes no real difference). The other wire we run from operating switch to binding post 11. We then run wire from binding post 8 or 9 to the other lamp binding post, set adjustment lever 7 on contact 1 and switch on the current, adjusting contact lever 7 by moving to the right until desired flow is obtained. The current enters at binding post 11 (the actual direction may be the opposite, but that makes no difference in the effect), passes to post 6 through wire 12, into and along lever 7, through contact 1 (if lever is on that contact), along wire from contact 1 to bottom of grid 13 at A, up grid 13, across X, down grid 14, across and up grid 15, down grid 16, and so on until it reaches F (if wire to lamp is attached to binding post 8, or to G, if attached to binding post 9), along wire to binding post 7 and thence to the lamp. By thus connecting to post 8 we cut out grids 25 and 26, reducing the fixed resistance and giving greater amperage. If voltage is 110 to 120 it is best to make connection to binding post 9. If it is less than 110 use post 8. The rods 4—4 hold the grids together, and the nuts on these rods should always be kept set up tight. Adjustment lever 7 may be removed by taking off screw 5. Slate contact base may be removed by taking out screws H-H. 1 is a sheet metal support for the grid to reduce liability to breakage through a heavy jolt. 2 is the grid itself, also shown in Fig. 55. 3 is asbestos insulation between grid and support 1. Z, Fig. 57, is the spring contact between adjustment lever 7 and the contacts. This spring must make firm contact with the buttons at all times. Should contacts 1, 2, 3, 4 and 5 (Fig. 56) become roughened, carefully dress them up with a small file around which wrap No. 00 emery paper; at the same time smooth up face of spring Z. A new grid may be put in, should need arise, by removing nuts 4—4, Fig. 56, and, laying the grid bank on end, lifting off grids one at a time until the damaged one is removed. Be very careful, however, to keep the insulating and spacing washers (X—O, Fig. 56) in the same relative positions, or there will be trouble. Between grids 25 and 26 the insulation is at the bottom, the current carrying spacer being at the top. Between grids 24 and 25 the order is reversed, the insulation being at the top and the current connection at the bottom, and so on all through. Once understood it is very simple, but be sure you understand it before attempting to replace a grid.

Power's wire coil adjustable rheostat has precisely the same connections as has the adjustable grid rheostat, and instructions for one will serve for both, except that the method of connecting coils and grids is different, of course—not the connecting of the rheostat in the circuit, but connecting the coils and grids in the grid bank. The connections of the 220 volt grid rheostat in circuit are exactly the same as for the 110 volt. Its electrical effect and the amperage adjustment is the same, but there is more fixed resistance.

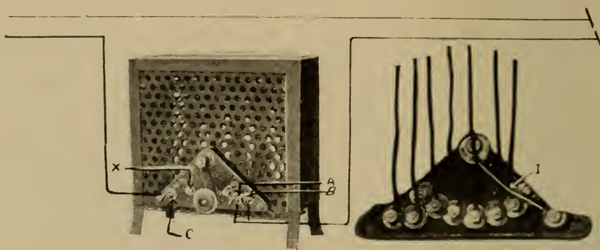


Fig. 58.

Fig. 58 illustrates Power's wire coil adjustable rheostat, and furnishes an enlarged view of the back of its contact base, which is also identical with the contact base of the 110 and 220 volt grid rheostat. Connections from line to lamp are made as shown, which also is the method of connecting the grid rheostat, shown in Figs. 56 and 57. When current of less voltage than 110 is used, contact should always be made with binding post 8 (Fig. 56). A coil may be replaced by loosening screws holding its top and bottom, removing the old coil and substituting the new, setting the screws up tight again.

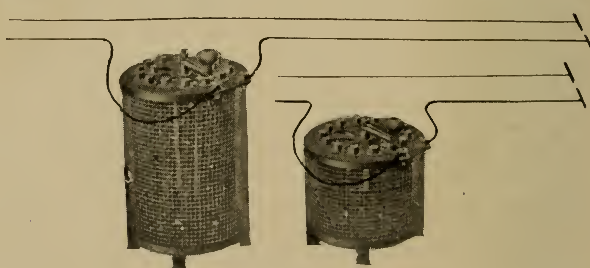


Fig. 59.

Fig. 59 shows Power's 220 volt adjustable wire coil rheostat; also the smaller 110 volt wire coil rheostat, of the same type, for use on 104 to 110 volts pressure. The larger, 220 volt, rheostat, may be used on any pressure from 52 to 220 volts. The method of connection is illustrated in Fig. 59. The sliding contact lever controls the amperage by varying the amount of resistance (number of coils used). When set, as shown in A, Fig. 60, it is ready to be used on 220.

With 220 volts pressure the lever may be moved to contacts 2 and 3, but beyond that the coils get too hot. Moving the lever from contact 1 to 14 has the effect of cutting out one or two coils for every contact, thus increasing the amperage, but never move the lever so far that the coils remaining in use get red hot. When

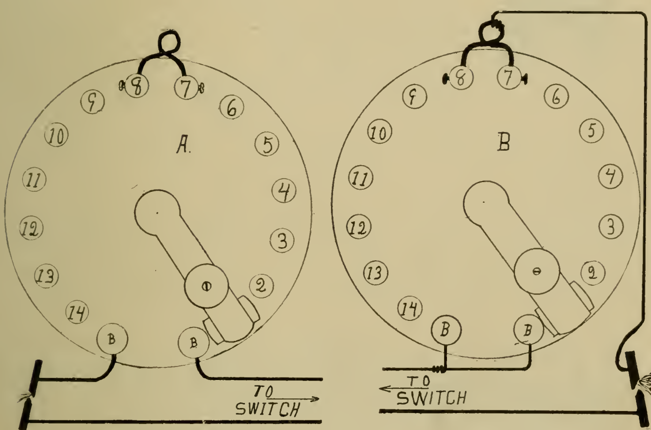


Fig. 60.

working on 110 volts the lever should be set on about No. 10 or 11. For lower voltage it may be still nearer contact No. 14, but No. 14 should never be used, since that makes a dead short circuit, eliminating all resistance. B, Fig. 60, shows the two sides connected in multiple. This connection may only be used where the voltage is 120 or less; never on higher pressure. This type of rheostat is not an "approved type," but is nevertheless a light, strong, well made rheostat, which is electrically very flexible. It is therefore most excellent for road work. The smaller, 110 volt rheostat, shown in Fig. 59, is connected as per A, Fig. 60. It cannot be connected as per B, Fig. 60.

MOTIOGRAPH RHEOSTATS.

The resistance devices, put out by the Enterprise Optical Co. as a part of Motiograph machine outfits, are mechanically exceedingly well made. The coils are separated from each other, so that one coil can be renewed without disturbing the others. The construction is solid, substantial and simple.

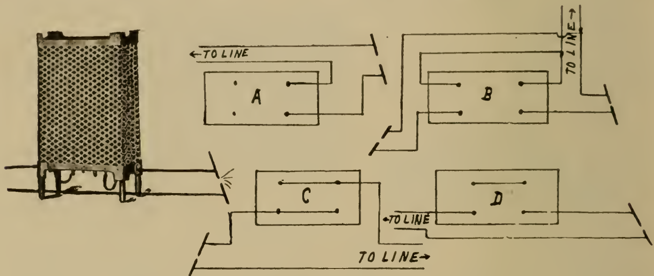


Fig. 61.

Their A. C. R. universal rheostat is illustrated in Fig. 61, together with the various connections. This rheostat is, in effect, and in fact, two separate resistances in one case, either of which may be used entirely independent of, or in conjunction with the other. At A, Fig. 61, we see one-half of the rheostat, connected in series with the arc. This connection gives 25 amperes. At B, Fig. 61, we see two lamps, each one connected to one of the resistances of the rheostat. This connection delivers 25 amperes to each lamp. At C, Fig. 61, we see the two halves of the rheostat, connected in multiple, supplying 45 amperes of current to the lamp. At D, the two halves of the rheostat are connected in series, supplying 12 amperes of current to the lamp. In all these connections we are assuming the voltage to be 110. The rheostat may be used on voltage ranging from 104 to 120, but the amperage delivery will be correspondingly lower or higher if the voltage is below or above 110. Connected as per D, Fig. 61, this rheostat may be used on 220

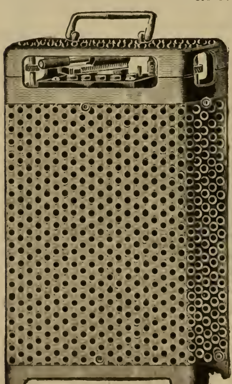


Fig 62.

volts pressure, delivering 25 amperes, but connections A, B, and C cannot be used for pressures in excess of 120 volts.

Fig. 62 illustrates the A. C. R. Underwriters' Model Adjustable Rheostat, which is made in three sizes for 110 volts, delivering a maximum of 20, 30 and 45 amperes; in one size for 220 volts, delivering a maximum of 25 amperes, and in one size for 220 to 250 volts, delivering a maximum of 50 amperes. There are but two binding posts to this rheostat, and there is only one way in which it can be connected, therefore instruction is unnecessary.

The "Dandy" rheostat put out with the Motiograph machine is simply one-half of the Universal in a separate casing. It is connected as per Fig. 54. In Fig. 62, B illustrates the "A. R. C" adjustable rheostat, Underwriters' Model, also put out with the Motiograph machine. It comes in five forms, having maximum capacity, respectively, of 20, 30 and 45 amperes for 110 volts; 25 amperes for 220 volts, and 50 amperes for 250 volts. The latter may also be used for 220 volts, but will have less amperage capacity on that pressure.

The Edison Rheostat.—This rheostat is designed for setting on a stand under or near the machine or on a shelf convenient to the operator. On the front of the rheostat is mounted a knurled composition handle; set into the end of this handle is a stamped plate, fitted with indicating arrows pointing in opposite directions to each other and directly under the arrow points are the words "on" and "off." If the handle is turned to the right in

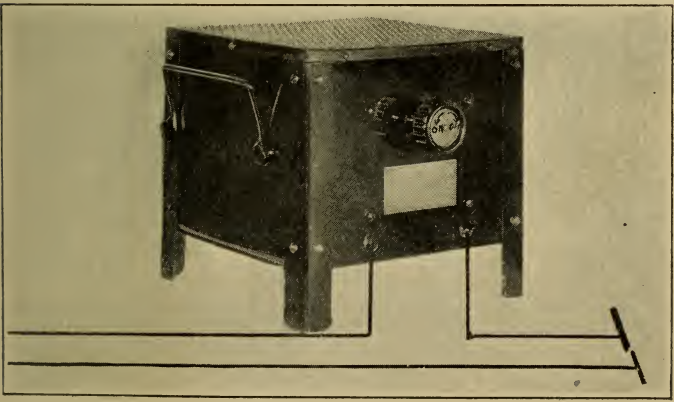


Fig. 63.

the direction of the arrow indicating toward the word "off," more resistance will be cut in and the current to the lamp will be decreased. If the operating handle is turned to the left as indicated by the arrow pointing toward the word "on," resistance will be cut out and current at the lamp increased. The lever operated by this handle, the contact buttons and the binding posts are all mounted on a slate base inside of the case, directly back of the operating handle, same being illustrated at B, Fig. 64.

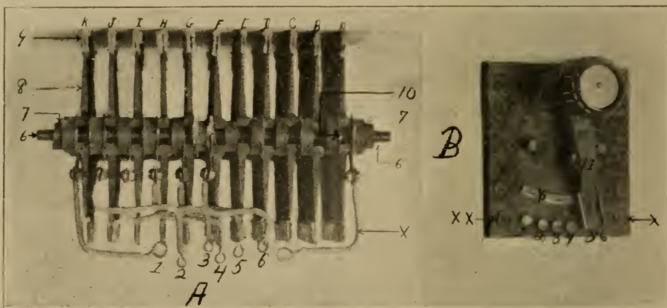


Fig. 64.

To connect the lamp leads to this type of rheostat they are passed through the holes in the bottom of the case, directly under the binding posts, and a screw-driver is passed through a hole in the front of the case, directly in front of the binding posts, to tighten the screws. Method of connecting is shown in Fig. 54.

The top and bottom of these rheostats are covered with perforated metal to allow free passage of air through the resistance and nothing should be set below the rheostat in direct contact with the bottom perforated metal, nor in contact with the top perforated metal, so as to obstruct the free passage of air.

The resistance material is made up of cast metal grids, A, B, C, D, E, F, G, H, I, J and K, Fig. 64, insulated with mica tubing and mica washers, one of the latter being shown at 10, Fig. 64. These grids are practically indestructible, and should not require replacing unless the rheostat has been subjected to a jolt sufficient to actually break the cast metal. Should a grid become broken through accident, it is an easy matter to replace it, but should a new grid not be on hand, a temporary repair may readily be made until a new grid can be secured. If the break is at the bottom of a grid, simply turn the rheostat upside down, remove the bottom piece of perforated metal, and make a connection across the break in the grid with a piece of copper wire, first cleaning the metal and then making sure to wrap the wire tightly so as to secure good contact between the wire and the grid. Or if it is preferred that a better repair be made, and there is time to spare, a clamp could be made to bridge across the break. If the break is at the top of a grid, then of course the repair would be accomplished in the same way by removing the top perforated cover. After a new grid is secured and ready to install, remove either the perforated bottom or top, the bottom being probably the easier to handle. Then loosen the large nuts on the ends of the rheostat, which secure the carrying handles. Next loosen the nuts 7—7, Fig. 64, on the rods inside of the case, allowing the grids to move freely on grid rods 6, Fig. 64. Do not remove the grids from the rods or you will give yourself the pleasure of rebuilding the entire bank, and probably will get them all disarranged in relation to one another. Simply have them loose on the rods and push the grids that are on one side of the broken one as far as they will go toward one side of the case, push the grids on the other side of the broken one as far as they will go on the other side of the case—and in this way get all the room you can at the point where the grid is broken.

Before removing the broken grid note carefully the position of the mica washers on the grid rods next to the broken grid, so as to get the washers in the same position when the new grid is put in place.

Remove the broken grid, slip one end of the new grid over one of the grid rods, making sure mica washer is in the right place, then drop the grid down, holding it on an angle to the grid rods and with the space gained from the angle of the grid together with a slight spring you may have to give to the grid, you will find it will slip in readily. Note carefully if the mica washers are in the right position on the rods beside the new grids, remembering one should be on one side at one end, and the other should be on the opposite side at the other end. If the washers are in the right position, push all of the grids back into their places and tighten up clamp nuts 7—7 on grid rods 6, Fig. 64, making sure to get them tight, or there will not be a good electrical contact between the grid ends. You can then proceed to put the casing together again. In assembling grids, it is exceedingly important to bear in mind the position of the mica washers. On the Edison moving picture rheostats, all grids are in series, and the mica washers must be so arranged that the circuit is not interrupted by a mica washer being where it should not be, and so that two grid ends do not touch where a mica washer should separate them.

Assuming in Fig. 65 each line to be a grid, the short double lines to be mica washers and black squares to be where grids are touching end to end, the grid, assembled, would be as shown. This you will note gives a continuous path from one end of the resistance to another; first, through one grid, then through the next, and so on. You can readily see that a misplaced washer will interrupt the circuit and that no current would pass that point, or if two washers were misplaced, one at each end, that two grids would be shorted so that the total resistance would be lower than designed.

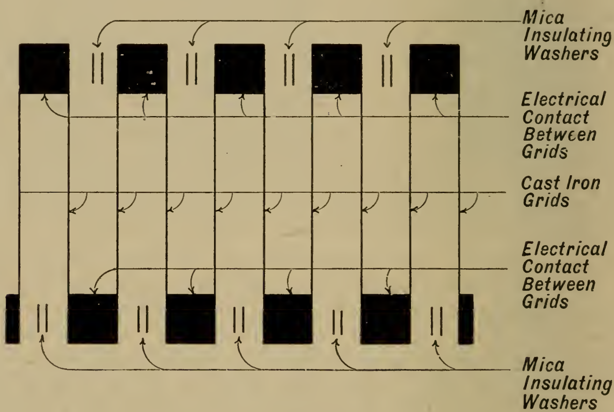


Fig. 65.

These rheostats are fitted with seven buttons; six "variable steps," and one "fixed step." This gives 7 degrees of adjustment of the current and the light. With the arc operating with an average gap at the carbons, and using a 25 to 40 ampere rheostat, the current flowing with the operating handle carried toward the "off" point as far as it will go so the lever is on the first button, about 25 amperes will flow. Carrying the lever to the second button will increase the current to about 27 amperes; to the third button, about 29 to 30 amperes; to the fourth button about 33 amperes; to the fifth button about 35 amperes; to the sixth button about 38 amperes, and to the seventh button about 40 amperes.

On the 40 ampere to 60 ampere size, with an average length of arc, and with the lever in the first position about 40 amperes will flow; on the second button about 43 amperes; on the third button about 46 amperes; on the fourth button about 49 amperes; on the fifth button about 53 amperes; on the sixth button about 57 amperes; on the seventh button about 60 amperes.

The current of an arc lamp and also the voltage will vary with the gap between the carbons. With the rheostat lever on a given point, decreasing the gap at the carbons will increase the current and decrease the voltage at the arc. Increasing the gap at the carbons will decrease the current and increase the voltage at the arc. To obtain a good light with a given current, attention must be given to the lamp adjustment. If the arc is too short the current will be high and the carbons will sputter; if the arc is too low the arc will sputter and the light will be very unsteady, probably losing the arc altogether, so that it will be necessary to restart the same. Do not set the rheostat lever at too low a position and try to get a good light by running the carbons too closely together. The results will not be good and constant attention will be required for lamp adjustment.

Do not set the rheostat lever at too high a current position and try to keep the current down by running the lamp with the carbons too far apart. This will also be unsatisfactory and require frequent adjustment of the carbons. Bring the carbons together, start your arc, separate the carbons where the arc operates nicely, bring your rheostat lever up to a point where you get a good light, and in this way you will get the best results with the least attention to the lamp.

The wiring connections for the rheostat and arc lamp are very simple. The rheostat is connected directly in series with the lamp, as indicated in Fig. 63.

Fig. 64 shows view of end of grid bank at A and at B the adjustment switch. A, B, C, D, E, F, G, H. I. J and K are the grids, one of which is shown at 51 Y 17, Fig. 66. 9 is a stiffener of metal lined with asbestos to prevent short-circuiting the various wires of the grid. 6 is the bank tie-rod of which there are two. In Fig. 64, A 10 is one of the insulating mica washers in place. The view at A is of the connection end of the bank and switch B attaches to the casing immediately in front of the bank, as indicated by dotted line. Wire XX, A attaches to back end of contact bolt XX, B; wire X, A attaches to back end of contact bolt X, B. Wires 1, 2, 3, 4 and 5 A attach to back end of contact buttons 1, 2, 3, 4 and 5 B. The electrical action is as follows: Current enters at X (it may actually move in opposite direction but the effect is the same), passes through contact bolt X, B, into wire X, A, and thence into grid A, across to grid B, C, D, E, and F. Now if lever 11 B happens to be set on button

6, then the current can pass through wire 6, through into lever 11 and across into bar Y, to which wire the other end of line wire is attached. If, however, lever 11 be set on contact 5, then the current must traverse grid G before it can escape through lever 11 and contact bar Y, and if lever 11 be on contact 1 the current must go through all the grids to wire 1 before it can get into lever 11 and bar Y, and thus reach the circuit wire. This is the electrical action of the rheostat.

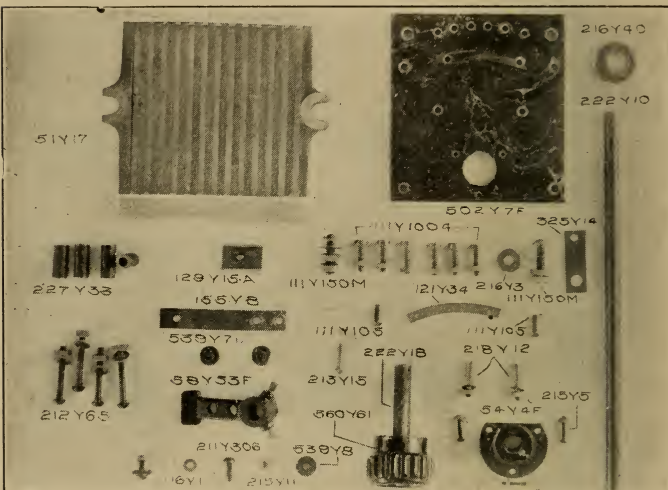


Fig. 66.

The various parts of the device are shown in Fig. 66, being designated by the manufacturer's stock number.

The Edison Underwriters' model rheostat, as shown in Fig. 63, is made in four sizes, as follows:

Voltage.	Range of Adjustment.
110	25 to 40 amperes.
110	40 to 60 "
220	25 to 40 "
220	40 to 60 "

WATER RESISTANCE

Water Resistance is a subject concerning which few operators have any accurate knowledge. It is not much used, true, but nevertheless, one can never tell when one will be called upon, by accident, or by reason of having to use temporarily 500 volt trolley current, to quickly improvise some practical form of resistance. Water resistance is perhaps the most feasible form of reliable resistance for temporary use, or for use with high voltage, where one has not the necessary rheostatic resistance at hand.

Water resistance, as commonly used, consists of a receptacle, usually an ordinary barrel, in which is placed a lead, steel or iron plate attached to the end of a wire leading directly to the lamp. The wire from the supply is attached to another iron, steel or lead plate, and is also placed in the barrel, the whole being covered with water, as shown in Fig. 67.

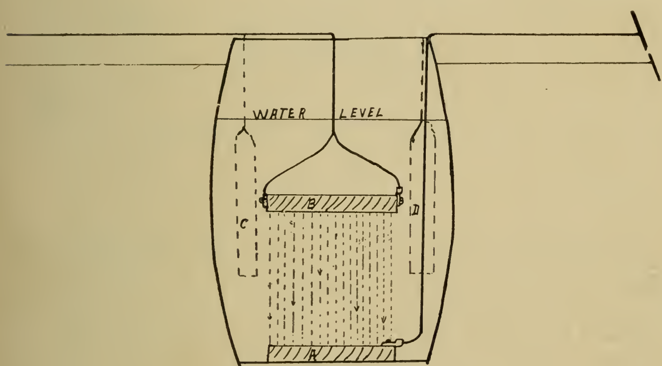
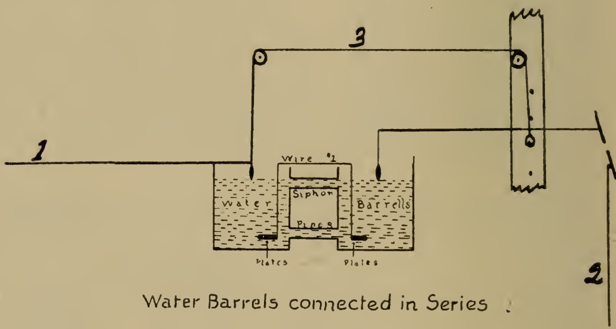


Fig. 67.

One of the metal plates (A) may be at the bottom of the water and the other (B) lowered, as shown, or they may be suspended at the sides of the cask, as per dotted lines C and D. This is an immaterial item. The main idea is to have the surfaces of the plates approximately parallel to each other, and have them maintained a fixed distance apart. The water offers the resistance. Current passes from one plate to the other, as indicated by dotted lines, Fig. 67.

Pure water, that is to say, ordinary water, such as comes from a supply pipe or well, has very high resistance. It is not suited to the work unless something be added to increase its conductivity. Sulphuric acid solution will do this, but is not usually employed for the reason that lead or carbon plates are necessary if it is used. The most common medium employed to reduce the resistance is common salt (Salammoniac, soda or copper sulphide in water may also be used). With the alkalines ordinary iron or steel plates may be used. Use an ordinary 10 cent sack of salt to the barrel.



Water Barrels connected in Series

Fig. 68.

In practice we use any common water-tight barrel filled two-thirds full of water for projection resistance. Theoretically, however, it is claimed that there should be one cubic inch of water for every watt being used. This, however, would be totally impractical for trolley current, since for a 40 ampere flow about 90 gallons of water would be required. We just use an ordinary sized barrel for ordinary voltages and for 500 or 550 volts use two barrels, as per Fig. 68.

Fig. 68 shows two water receptacles (connected for circulation, since thus an even temperature is maintained in the water of the two barrels), and a connection which amounts to two water rheostats in series. 1 represents wire from trolley or other supply. 2 is wire from negative lamp carbon to ground, and 3, regulating hoist rope, which must be a non-conductor. If the water gets too hot when using water resistance, it will be necessary to remove some and add cold water in its place. This necessitates also an addition of more salt, or whatever is used.

The resistance will be invariably proportional to the strength of the solution, i. e., the amount of salt or other chemical added to the water. Copper sulphide supplies the highest resistance. With a 1 per cent. copper sulphide solution there will be about a 100 volt drop for one inch separation of the plates. A 10 per cent. solution will give about 10 volts drop for each inch separation of the plates. A 5% soda solution will give approximately 10 volts drop for each inch separation of the plates. Salt gives slightly higher resistance than does soda. Plates are supposed to have a density of one ampere per square inch.

We do not pay much attention to theory. We connect as shown, fill the barrel two-thirds full of water, throw in a double handful or two of salt, strike an arc and adjust the plates until we get the desired amperage, as nearly as we can guess at it. Of course, if one is to run for any considerable length of time with water resistance, one would do well to study the matter more closely. The haphazard plan applies only to temporary emergency resistance for use during one show, or one evening. For such temporary use we may even use two pieces of one-inch gas pipe instead of plates, wrapping the raw wire tightly about their upper ends and then covering one foot, including the wire connection, with insulating tape. Just place the two pipes in the barrel, one on either side, being very careful that they do not come into contact with each other, thus establishing a dead short circuit. It is much the best to place a short board on edge across the bottom of the barrel to prevent accidental direct contact of the two pipes. The writer has often fixed up such a temporary resistance in less than half an hour when on the road. The rheostats were jammed in shipment or perhaps were lost. We would arrive in a town, say at 6 P. M., with a show to be given at 8 and no resistance. A barrel, two four-foot pieces of pipe, some water and salt, and presto, we were supplied with excellent temporary resistance, though very unpleasant to work with by reason of steam and heat from the water and constantly varying resistance due to change of temperature of the water and variation of solution, as cold water was added and hot water drawn off. But, regardless of the discomfort of the operator, the show went on, and that was the main point. When no pipe could be found I have even used a couple of fish-plates (plates that railway rails are joined with), attaching the wires to them and suspending them in the water.

The operator, particularly a few years ago, when appliances were crude and accurate knowledge scant, had to be a man of resource. He was expected to evolve miracles, and, to his credit, he generally made good.

Transformers and Choke Coils

BEFORE going into details regarding the transformers, broadly speaking there is a similarity of action between all electrical appliances which depend upon induction for their action. While this is true, still there is a distinct difference, and this difference is such that the various devices are necessarily classed in different groups. The transformer group includes all appliances which transform voltage from one pressure to another. The choke, or reactance coil simply forms an inductive resistance in the circuit.

In Fig. 69 we see at No. 1 a diagram representation of the choke coil, also known as the "reactance" coil. No. 2 is a diagrammatic representation of the regular transformer, and No. 3 is the auto transformer. The coil generally consists of one or two cores of iron around which a number of turns of large insulated copper wire is wound. The effect of one of these coils upon the line is the same as the rheostat, but due to the fact that the current in a choke coil lags behind the line voltage or electro motive force, the magnetism created in the iron core sets up a counter current which opposes the line voltage, thereby not only reducing the voltage, but at the same time effecting a saving in the watts consumed. When a coil of this description is used, it is connected in series with the arc, exactly as would be an ordinary rheostat, and if 50 amperes are required at the arc, there will be taken from the line 50 amperes, consequently the line wires, fuses, switches and wiring inside the building must be of a capacity of 50 amperes, or the same as for the rheostat. There is a certain loss in the choke coil which, while being much smaller than in the rheostat, is still considerable. Another matter of importance is that whenever the rheostat, or any form of choke coil, is used, there is considerable flaming at the arc and it is difficult to centralize the illuminating power in a sufficiently small spot on the carbons to permit of proper focusing. This fact accounts for the presence of an uneven field of light on the screen on which there is present what is commonly termed a "ghost," consisting of a shadow in the center or at one side which may be either all black, or more often of purple color, seriously interfering with the brilliancy of the picture.

With the regular transformer, No. 2, Fig. 69, the transforming ratio is two to one, except for the slight loss in the transformer itself, so that if 25 amperes is taken from the line at 110 volts pressure, it generates an entirely separate secondary current of approximately 50 amperes at 53 volts. We, therefore, see that the wire of the secondary coil ("Primary" coil is one connecting to supply wires—"Secondary" coil is on lamp side), and circuit must necessarily have twice the current carrying capacity of the primary circuit and coil. This line current of 25 amperes flows from the line to the primary coil, through the primary coil and back to the line, its energy being expended in keeping up the density of the magnetic flux against the reaction of the secondary current.

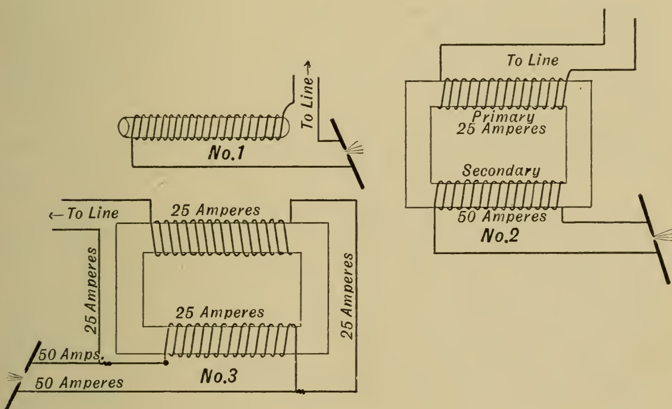


Fig. 69.

Now, suppose we take from the secondary coil only 25 amperes, and connect it in such a way as to use the 25 amperes with primary current at the lamp, as in Fig. 3. There will then be 50 amperes at the lamp and only 25 taken from the line, and only 25 amperes in any coil of the transformer. This plan of transformer wiring constitutes the auto type. The advantage claimed for it is much less copper loss, hence higher efficiency with less weight for the same secondary capacity. In view of the fact that the transformers we are considering have a ratio of two to one, and convert 25 amperes at 110 volts into 50 amperes at 53 volts, etcetera, the reader naturally asks how the manufacturers of these current savers can claim a saving on 110 volts of 60 per cent., approximately, as compared with a rheostat. The power factor of the transformer now enters into the question.

Briefly it is the ratio between the *apparent* watts and the *actual* watts. Apparent watts are obtained by multiplying the amperage by the voltage. In the above case it would be $50 \times 53 = 2,650$ watts. Actual watts are those actually used to produce power, or light, and, fortunately for the user, those registered by the meter. All moving picture arcs on alternating current use between 30 and 35 volts. The transformers used as current savers are so designed that the instant the arc is struck the voltage drops to between 30 and 35, depending on how far apart the carbons are. The actual watts consumed by the moving picture arc are, for example: $50 \times 35 = 1,750$ watts; therefore the saving would be the difference between $50 \times 110 = 5,500$ watts, and 1,750 watts or more than 67 per cent. The power factor in this case would be the ratio between 53 volts and 35 volts, or whatever the arc voltage happens to be. Assuming that it is 35, the power factor is then $35 \div 53 — 66\%$.

With this general explanation of the different types of inductive resistance, we will now take up the topic of transformers.

TRANSFORMERS

As is explained under "Resistance," resistance through wire coils, or grids, is an enormously expensive, wasteful thing. In fact, resistance is for the very purpose of breaking down and wasting, or dissipating all pressure in excess of the arc voltage. Waste is costly and should be avoided wherever possible, and it is quite practical to avoid it, when dealing with alternating current, by the use of what is known as a "transformer."

A transformer is a device designed to reduce, or increase A. C. voltage, without altering the wattage, or total expenditure of electrical energy, to any appreciable extent. This means that the amperage is increased in nearly the exact ratio in which the voltage is reduced. To accomplish this without appreciable loss, however, it is necessary that the transformer be well designed and well constructed, both mechanically and electrically.

It must be remembered that a large number of amperes, at low voltage, is equal in energy (power) to a small number of amperes at high voltage; thus: 10 amperes at 1,000 volts ($10 \times 1,000 = 10,000$ watts) is equal in electric energy to 1,000 amperes at 10 volts ($1,000 \times 10 = 10,000$ watts). Each would do the same amount of work. Ten amperes at 2,000 volts is the same, in power or energy, to 400 amperes at 50 volts. The proof is: $2,000 \times 10 = 20,000$ watts and $400 \times 50 = 20,000$ watts.

A good transformer will take 20 amperes at 110 volts pressure from the line, and deliver, approximately 40 amperes to a 35-volt arc. Remember that as watts equal volts multiplied by amperes, we have $110 \times 20 = 2{,}200$ apparent watts taken from the line, and, due to the power factor, $35 \times 40 = 1{,}400$ actual watts consumed at the arc, and registered by the meter. The rheostat would waste $(110 - 35) \times 40 = 3{,}000$ watts in delivering 40 amperes to the arc from a 110 volt line. In order to use 1,400 watts in the production of light, the rheostat would waste 3,000 watts; whereas the transformer would hardly waste to exceed 50 watts. The enormous saving is evident.

The transformer is now used for two separate and distinct purposes in connection with the theater. A. C. is ordinarily brought to the building on street mains carrying high pressure—high tension lines they are called. The voltage on these lines is usually 1,100 or 2,000 — sometimes even higher. It would, of course, be highly unsafe, from any and every point of view, to bring wires carrying such voltage into a building. A transformer is therefore installed outside, usually on one of the line poles, and by it the pressure is reduced, usually to the ordinary commercial voltage of 110 or 220. This is the function of the outside transformer.

But, as has been explained, for use in the projection arc lamp the current pressure must be still further reduced to 30 or 35 volts. One modern method of doing this is by means of a device termed, by various manufacturers, Economizer, Inductor, Compensarc, Transformer, etcetera, but which is nothing more or less than a low voltage transformer (No. 2, Fig. 69), acting precisely the same as does its high tension brother out on the pole, except that instead of reducing from 1,100 or 2,200 volts to 110, it reduces from 110 to 30 or 35.

While projection lamps ordinarily operate from 110 or 220 volt lines, sometimes they are attached to lines carrying higher voltage. The voltage may run as high as 550. The use of 550 volts, or even 220 volts, through a rheostat, is by no means to be recommended, for the following reasons: (1) The rheostat must drop the pressure from 550, 220, or whatever the voltage may be, to approximately 35, wasting in the process wattage equivalent to the difference between the line voltage and the arc voltage multiplied by the amperes, thus: On a 550 volt line, using 30 amperes, the waste should be $(550 - 35) \times 30 = 15{,}450$ watts. In other words, we would be wasting 15,450 watts which would register on the meter, in order to use, at the arc, $35 \times 30 = 1{,}050$ watts. It is thus seen that the use of a rheostat on high voltage is practically prohibitive. (2) The majority of

500 volt circuits are grounded circuits, and would therefore be very dangerous to the operator. Should he himself be grounded and touch a "live" part of the rheostat, or lamp, the shock might be sufficient to do him severe injury, and, under certain circumstances, might even be fatal. Such circuits are usually D. C., however, and a motor-generator set is much the best thing to employ to reduce the voltage to arc pressure—see motor generator, page 183. Of course, if the current is A. C., then a transformer may be used.

The transformer depends on the following electromagnetic principle for its action: All electric wires carrying current are surrounded by what is called a magnetic field. That is to say, there is magnetism surrounding every wire which carries current. Now, if another wire be placed within the magnetic field of a wire along which current flows, there will be an impulse of current induced in that wire every time the current is stopped or started in the current-carrying conductor.

Fig. 70.

In Fig. 70 we see the end of a wire, A, carrying current, and surrounded by circles representing its magnetic field. Just below, but crossing its magnetic field, we see a second wire, B. Now, if the current be stopped or started in A, there will be an impulse of secondary induced current flow in wire B, at that instant, but not again until the current in wire A be again stopped or started. Now, if the current in wire A be alternating, it is starting and stopping may times every second, and the current impulses will become so frequent in wire B that a steady flow will result. The energy induced in wire B is taken from, and must be subtracted from the current flowing in Wire A. This, briefly, is the underlying principle upon which all transformers work. Also it explains why they cannot be used on D. C., which only starts and stops when the switch is opened or closed.

The above illustration is, however, of use merely in illustrating the principle itself. In practice the current generated, or induced in wire B, would be of such extremely low voltage and slight quantity as to be utterly useless for any commercial purpose whatever. Like the generator the strength of the current induced depends on the number of magnetic lines cut by wire B, and their number will depend (a) upon the strength of the "field" and (b) the number of times wire B crosses it. The strength of the field will depend upon how it is "built up."

If wire A be wound a number of times around an iron core it will magnetize the core and set up a powerful magnetic "field." This fact is made use of as follows: A large number of thin plates of soft iron are cut in suitable form, one of which is shown at A, Fig. 71. These sheets should not be more than 1-64 of an inch in thickness, and some manufacturers use sheets as thin as 1-100 of an inch. The thinner the better. The core is built up by clamping a large number of these sheets tightly together (first having painted them with some insulating material), as shown in B, Fig. 71. This is called a "laminated" core, the sheets representing the laminations. The number and size of sheets in a core is determined by the proposed capacity of the transformer. The sheets must be clamped together with considerable pressure or there will be vibration and objectionable noise in the nature of a loud hum.

After the core is otherwise completed it is wound with some insulating medium, and again painted with an insulating compound. It is then ready to receive its windings of insulated copper wire as shown at C, Fig. 71. At C we see the two windings. The one connecting to the line (higher voltage) is called the "primary." It is of smaller wire because it will not be called upon to carry such heavy amperage as the "secondary," indicated by the heavier wire. In the operating room transformer (Inductor, Economizer, Compensarc, etcetera), the primary coil connects to the feed wires, and the secondary to the lamp. Each ampere taken from the 110 volt line will appear approximately as $110 \times 1 = 110 \times$ power factor (66%) = 72.6 watts $\div$ 35 (arc voltage) = 2 amperes approximately at the arc. Allowing for some slight waste, let us say, each ampere taken from the 110 volt line will appear at the arc as 2 amperes on the secondary. With 220 volts on the line each ampere will appear approximately as $220 \times 1 = 220 \times$ power factor (66%) = 145.2 watts $\div$ 35 (arc voltage) = approximately 4 amperes at the arc. You will thus see that the secondary winding must be heavier wire than the primary. This also will explain why you can pull 50 amperes at the arc with 25 ampere fuses on 110 volt primary, or 12½ ampere fuses on a 220 volt primary. If you were using a rheostat, you would have to have 50 ampere fuses in both cases.

The voltage of the secondary, hence the amperes delivered against the resistance of the arc, will depend on the relative number of times the wires composing the primary and secondary coils are wound around the core legs. The more turns the primary coil contains, in relation to the turns of the secondary, the higher will be the voltage in the secondary, hence the greater the number of amperes delivered against the resistance of the arc. This principle is made use of to vary the amperage at the arc, by means of a suitable arrangement which cuts out, or cuts in some of the turns of the primary coil, thus changing its relation to the secondary and varying the secondary voltage. This is illustrated at C, Fig. 71.

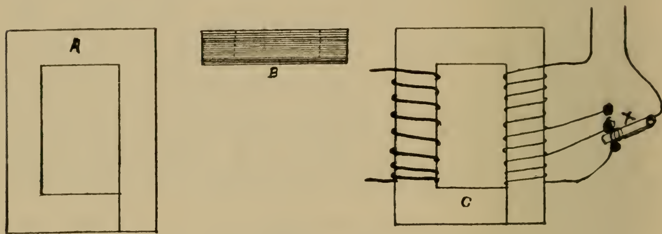


Fig. 71.

It will readily be seen that by moving lever X, a portion of the coil will be cut out or cut in, according to which way it is shifted. This is precisely what takes place when you move the adjustment lever on a Compensarc, Inductor, Economizer, etcetera, or make a different wire connection with those transformers in which the lever is absent, and variation of amperage is accomplished by changing wire connections.

A good transformer should give off no appreciable noise. There are times when it will get so hot that it will be exceedingly uncomfortable to the hand, but the temperature still not be dangerous to the device. Transformers well made should stand a temperature rise of 70 degrees Fahrenheit, above the temperature of the air. If, for example, the air in the operating room is 80 degrees, and the transformer has a temperature rise of 70 degrees, it would then be operating at a temperature of 150 degrees, which is altogether too hot to place the hand on it, nevertheless it would not be dangerous to the device. The hand cannot be, therefore, depended upon in such cases. A thermometer applied to the windings should always be used. A transformer cannot be used on direct current.

A transformer should not be used on a current of different cycle than that for which it was built. It should only be used on the voltage for which it is designed, though a 110 volt transformer may be used on 104 volt current, also on 120, though it may be slightly overloaded on the latter. On 104 it will not de-deliver its rated capacity. The overload caused by using a 110 volt transformer on 120 volts is not sufficient to do damage, if the machine be well designed and well constructed. A well built, well designed transformer, used on the voltage and cycle it was designed for, should last indefinitely, as there is very slight deterioration and no mechanical wear at all.

If at any time an odor of burning insulation, or smoke should come from the transformer, cut off the current at once and do no again use it until the damage has been repaired. It is an indication that one of the coils is burning, due to overload or some fault in the insulation. The coil must be removed and rewound. This is a job for the manufacturer. If you continue using it you will largely increase the damage and may possibly ruin the whole transformer. At any rate you will largely add to the cost of repairs.

Transformers should be set on insulation, as directed for rheostats. It should be borne in mind that transformers, and choke coils, when charged with the electricity in huge magnets, have a strong attraction for iron. You cannot insulate against magnetism. Distance is the only thing which will overcome it; therefore, when installing such a device in an operating room lined with sheet iron, the device should be placed at least 10 to 12 inches away from the sheet metal. If this is not done, a loud humming noise will result, and also a slight decrease in the amperage at the arc, which consequently will affect the light on the screen. Remember that magnetism will have the same effect on the iron covering the floor as it would on the iron covering the walls themselves.

Different manufacturers call their operating room transformers by different names, and make them in different shapes and sizes, but in general the electrical action of all of them is the same. There is, however, a wide difference in the practical performance of different makes. It is well, therefore, to investigate carefully before making a purchase. You should secure a written guarantee that there will be no appreciable noise in the transformer itself, and no excessive noise in the lamp carbons.

In ordering transformers give the exact voltage and cycles of the current.

If your picture exceeds 12 feet in width you should have a transformer with maximum capacity of not less than 60 amperes.

Transformers are made both to increase and decrease the voltage. If the turns in the secondary coil exceed those in the primary, voltage will be increased. If the primary coil turns exceed those of the secondary, the pressure will be lowered. The wattage taken from the line, in either case, will be equal to the wattage of the secondary, less a slight loss in the transformer. The step-down transformer (the Economizer, Inductor, Compensarc, Fomostat, Economy Transformer, etcetera, are step-down transformers) may be changed into a step-up transformer by connecting the line wires to the secondary. You will, therefore, see that no mistake must be made in connecting. The contacts marked "LINE" are the primary and to them must be connected the lines from the supply. The secondary contacts are marked "LAMP" and to them you must connect the wires leading to the lamp. It does not matter which wire runs to the top or bottom carbon of the lamp.

Should you reverse the connections—that is to say, connect the supply wires to the binding posts marked "LAMP," and the lamp wires to those marked "LINE," you would have a very dangerous condition. A shock from a lamp so connected might prove very serious.

Some pole (outside, high voltage) transformers are constructed with half the primary coil on each leg of the core, the two connected together; also the secondary on each leg, so connected. Such transformers may be made to deliver two pressures on the secondary, according to how they are connected. Usually these pressures are 110 and 220 volts. Operating room transformers are not made that way, however.

While the operator will ordinarily have no occasion to do anything with the outside high voltage transformer, and while it is not advisable for any but an experienced electrician to attempt to do anything with this transformer, still the operator should know a little something about it, since the traveling operator will be forced at times to change the fuses and maybe to connect his wires on the secondary circuit near the transformer. Should the road man be obliged to give a show in a church or other building, where the wires leading into the building are too small, but the pole transformer is large enough to carry the load, he may carry his own No. 6 wires out of a door or window, to the pole transformer, supporting them in any convenient manner, high enough to be out of reach of persons standing on the ground. He must then strip the insulation from the secondary wires for about two inches, right up close to the transformer, and, having scraped the wires thoroughly to insure good contact, attach his wires by wrapping them three or four times around the transformer secondary wires very tightly. It will, however, first be necessary to examine the plate on the transformer, if it has one, to see if it, the transformer, is large enough. The capacity will probably be expressed in kilowatts, thus: Secondary, 2 kilowatts, 110 volt. This would mean that the secondary is 110 volts, 2,000 watts capacity. Divide 2,000 by 110 and we see that the transformer will deliver only about 19 amperes on the secondary without overload. It will also be necessary to examine the fuses.

In either side of the transformer will be found a cast iron plug, which either pulls or screws out. These plugs carry the fuses. You will probably find the fuses to be very small, possibly not much larger than a heavy thread. It must, however, be remembered that if the primary is carrying 2,200 volts, 3 amperes from the primary will become 60 amperes on the 110 volt secondary. The power factor of this type of transformer is very high, and cuts no figure. It is figured as follows: Primary voltage multiplied by amperes give the watts taken from the primary, which divided by the secondary voltage (usually 110 volts) gives the secondary amperage, thus: Supposing the primary voltage to be 2,200 and the fuses of 3 amperes capacity, and the secondary 110 volts. $2{,}200 \times 3 = 6{,}600$, which divided by 110, gives 60 as the secondary amperage those 3 ampere primary fuses will supply. Let me caution you, however, to be very careful in dealing with the pole transformer, since should you touch the two primary wires the shock would kill you. Also, if you overload the transformer too much you may burn it out. It is best, where possible, to consult the superintendent or an electrician of the plant in regard to such matters, securing his permission to use a certain number of amperes through the transformer. Commercial transformers will stand a pretty heavy overload for a time without injury.

So far as the outside high voltage transformer is concerned, it is seldom or never necessary to attach an adjusting device, but in projection work an adjusting device enables one to increase or decrease the number of amperes delivered, and this is imperative for the following reasons: (a) A large picture requires much heavier amperage than is necessary with a small one, if the curtain illumination per square foot is to be maintained at a certain standard of brilliancy. (b) The density of different films or of different scenes in different films varies widely, and it, of course, will be readily understood that a dense film should have stronger light than one in which the pictures are clear and quite transparent. (c) The line voltage is frequently subject to fluctuations. It may be high in the afternoon and low in the evening, or vice versa. An adjustment is necessary to compensate for this variation in voltage.

There are on the market to-day perhaps a dozen or more different low voltage transformers designed for operating room use. It would be impractical to deal in detail with all these various devices, many of which are very little known and very little used. There are others, such as the Edison Transformer, Power's Inductor, Hallberg Economizer, and the Compensarc, known and used all over the country; also the Formostat and the Preddy Economizer, which are widely known and used on the Pacific Slope. These devices are in such common use that a detailed description of them seems to be necessary.

THE EDISON ECONOMY TRANSFORMER

The Edison Company claim a very high efficiency, and a simple adjusting mechanism for their transformer, description of which, with instructions, is as follows:

The Wiring Connections.—The Edison Economy Transformer, illustrated in Fig. 72, has five lead wires entering. At one side, directly under that part of the top in which the word

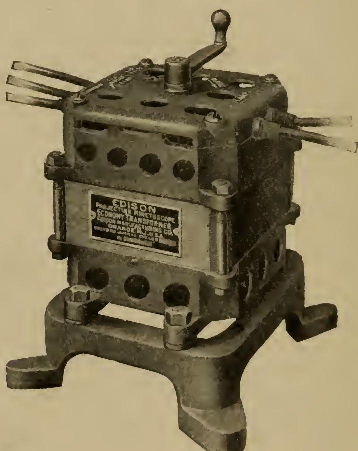


Fig. 72.

"Lamp," Fig. 73, is cast, are the secondary wires, which are to be connected directly to the carbon holders on the lamp.

The three wires entering the opposite side are primary lines (from the street mains) to the transformer. The wire to one side, and directly under the word "Common," is the "Common" wire, always to be connected to one side of the line switch. One of the other two wires is to be connected to the other side of the line switch, but which one is to be connected and which one is to be left "dead," will depend on the line voltage.

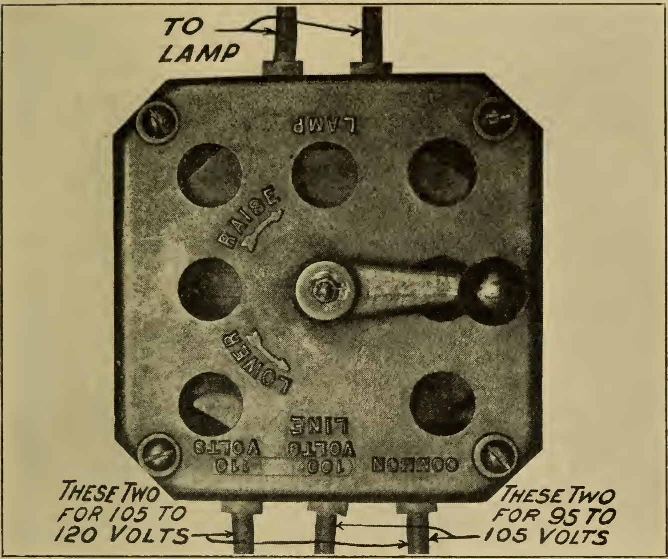


Fig. 73.

On 110 volt transformers, it will be noted that directly above one wire the case is lettered 100 volts, and directly above the other wire is the marking 110 volts. If the line voltage is 105 volts, or less, say 104, 100 or 95 volts, the wire directly under the 100 volt marking should be connected to the opposite side of the line switch to which the wire marked "Common" is connected, and the wire under the 110 volt marking should be taped up "dead." Should the line voltage be greater than 105 volts, say 108 volts, 110 volts, 120 volts, the wire under the 110 volts marking should be connected to the opposite side of the line switch to which the wire marked "Common" is connected, and the wire under the 100 volt marking should be taped up "dead." The end of the wire not in use should be carefully taped to prevent accidental contact between its end and live parts or with "ground." For connection diagrams, see A and B, Fig. 74.

On 220 volt transformers, the two outside wires will be found to be marked 200 volts and 220 volts instead of 100 volts and 110 volts. When, in connecting 220 volt apparatus in circuit,

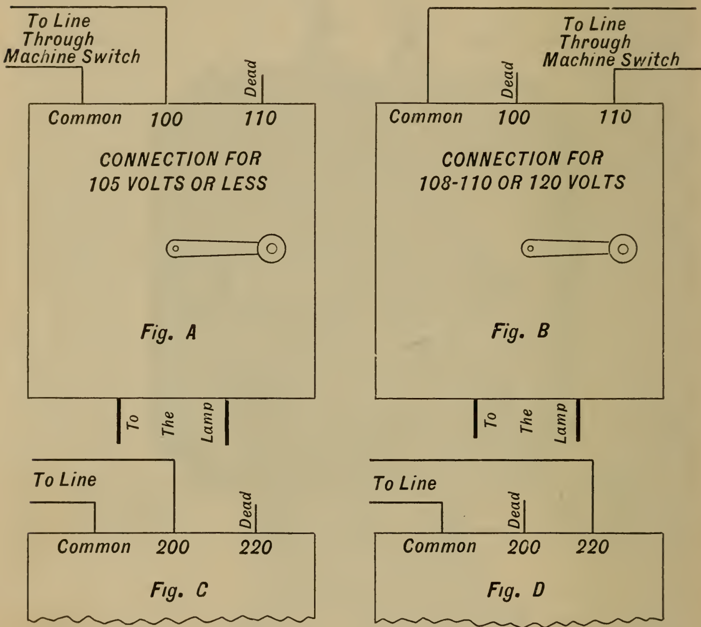


Fig. 74

it is found that the line voltage is 210 volts or less, the wire under the marking 200 volts should be connected to the line, and the wire marked 220 volts should be taped up. If it is found that the line voltage is greater than 210 volts, say 220 volts, 230 volts or 240 volts, then the wire under the marking 220 volts should be connected to the line and the wire under the marking 200 volts should be taped up. These connections are indicated in Figs. C and D, Fig. 74.

Range of Adjustment.—By referring to Fig. 73, it will be noted that there is a handle on the top of the transformer case. This handle operates the adjusting plugs for varying the current at the arc. Cast into the cover on top of the transformer case, Fig. 73, and directly under the handle, will be noted indicating arrows and the words "Raise" and "Lower." The turning of the lever to the right, or in the direction indicated by the

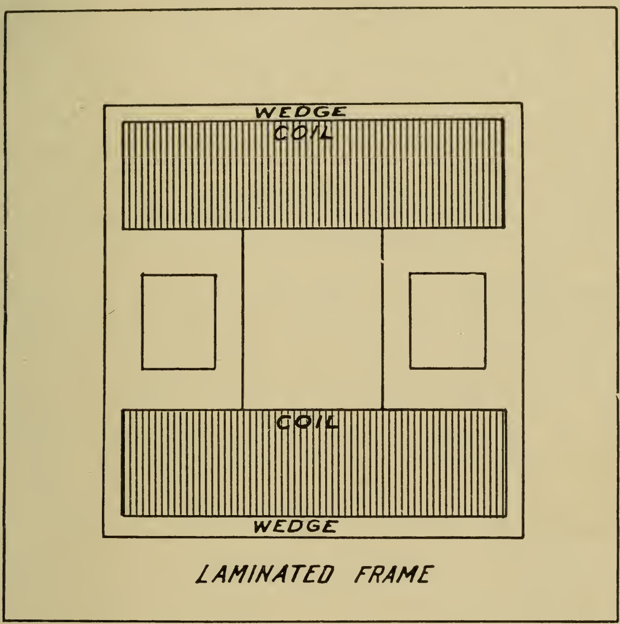


Fig. 75.

arrow directly below the word "Raise," will increase the number of amperes at the arc. The turning of the lever in the direction indicated by the arrow directly below the word "Lower" will decrease the amperes at the arc. The turning of this handle changes the adjustment by raising and lowering leakage plugs in the magnetic circuit. These leakage plugs are placed between the primary and secondary windings. When the handle has been turned in the "Lower" direction as far as it will go, the plugs are in a position to by-pass a considerable number of the magnetic lines set up by the primary winding, so that there is less voltage set up in the secondary winding. Turning the handle to the right, that is, in the "Raise" direction, gradually raises the plugs, thereby reducing the amount of by-passed lines, allowing a greater number of magnetic lines to thread the secondary coils and produce a correspondingly higher voltage.

The primary and secondary winding are secured to the iron core by means of wooden wedges, as per Fig. 75. These wedges should be driven in tight so that the windings will be held rigid. When the top casting is removed try to shift the windings by hand. If the windings are loose, tighten by driving in on the wedges from the outside ends. The transformer need not be taken apart other than that the top must be removed; then slip a chisel down between the winding and the frame and tap the chisel to drive the wedge tighter. Fig. 75 shows plan of transformer with the top casting removed. The raising and lowering of the plugs produces an adjustment without steps, or contacts, giving gradual adjustment, very much the same as the flow of water is adjusted by a globe valve.

Quiet Operation.—The Economy Transformer is claimed by its makers to be practically noiseless in operation, but should one become noisy after it has been in service, there are three adjustments, any of which may require attention: (1) The nut on top of the handle may have become loose. The screw shaft to which this handle is fastened is fitted with a shoulder below the top casting. This shoulder is brought up against a spring washer on the under side of the top casting. This nut on top of the handle should be set up sufficiently tight to compress the spring washer to almost a flat. This means that the nut on top of the handle should be kept moderately tight. Of course some judgment must be used so as not to get the nut too tight or the handle will turn hard, and be objectionable. (2) The leakage plugs, which are raised and lowered by the turning of the handle on top of the Economy Transformer, are fitted with phosphor bronze springs on their sides. These springs hold the plugs rigid between the walls of the supporting guides. Should these springs not hold the plugs rigid, they should be bent to give them greater tension. (3) The thread on the shaft to which the handle is fastened should make a good fit in the cross-piece to which the plugs are fastened. A loose fit at this point will not make the transformer noisy, but will cause it to hum slightly.

Operation.—To obtain a good light the carbons should be adjusted for about ⅛-inch gap between the carbons. Then the transformer adjusting handle should be turned to a position where the best light results are obtained. This will vary with the size of the picture and with the density of the picture on the film, and with the voltage of the street mains. With a comparatively small picture and a film of ordinary density, with the line voltage about equal to that for which the transformer is designed, say 110 volt line on the 110 volt tap, and with a good screen, a good light should result with the handle of the Economy Transformer turned to the "Lower" position as far as it will go. On the other hand, with a picture of larger size, with dense film, with line voltage low, say 106 volts on the 110 volt transformer tap, it will be necessary to turn the handle on the Economy Transformer several full revolutions in the "Raise" direction, and probably to the extreme "Raise" position to obtain a good light. These are extreme conditions, and for intermediate conditions the proper adjustment will be found readily at some point between the extreme "Lower" position and the extreme "Raise" position. There are fourteen full turns between the extreme "Lower" position and the extreme "Raise" position.

Current and Voltage at Lamp.—With the carbons adjusted to a ⅛-inch gap the following voltage and current conditions can be expected at the lamp, with different positions of the Economy Transformer handle. This table also gives the watts at the primary, or, in other words, the watts taken from the line:

The Line Voltage on this test was 106 volts.
The 110 Volt Tap was connected to the line.

Position of handle.	Amperes at arc.	Volts at arc.	Watts from line.
Lowest	40	36.5	1,540
4 Turns out	51	36.2	1,920
8 Turns out	59.5	34.2	2,120
12 Turns out	60.3	39.5	2,480
14 Turns out	63	40	2,620

The above readings are taken from definite handle positions, and it is obvious that turning the handle either way the above-mentioned positions will, of course, change the amount of current in proportion to the change made in the handle position, and the current will be increased or decreased, depending on whether the handle is turned in the "Raise" direction or in the "Lower" direction. The handle need not be turned a full revolution to effect a change, as each fraction of a turn of the handle means a percentage of change in the current.

Adjusting the Carbons will also change the amount of current at the lamp and the voltage at the lamp. For instance: Assume the adjusting handle to be in a certain position, and not changed, and that the arc is operating with a certain gap between the carbons. There will be a certain voltage across the carbons and a current of so many amperes will be flowing. If the lamp then be adjusted, bringing the carbons closer together, the voltage across the carbons will decrease and the amperes will correspondingly increase.

The Line Watts Will Vary in almost direct proportion to the product of the amperes times the volts at the arc until the carbons are brought in direct contact with one another, so that they are in actual short circuit, under which condition the line watts will become quite low. Assume, on the other hand, however, that instead of adjusting the carbons closer together they were moved farther apart. Under this condition the volts across the arc would increase and the amperes flowing would decrease, with the line watts varying in proportion to the product of the amperes flowing through the lamp times the volts across the lamp, and if this opening of the gap between the carbons were continued to a fairly wide gap the lamp would go out and the line watts drop to practically nothing.

THE HALLBERG ECONOMIZER

The "Hallberg" A. C. Economizer, top of which is shown in Fig. 76, is a specially designed transformer of the semi-constant current type, which means that it will take the line current at a fixed potential and will deliver on the secondary side a practically steady ampere flow, irrespective of the length of the arc.

The "Hallberg" A. C. Economizer consists of a continuous rectangular core. On one core leg there is put a primary winding; on the opposite core leg there is placed another coil or winding of larger cross-section wire to which the arc lamp is connected. The primary coil has one beginning end brought in through Terminal No. 1, Fig. 76. The end of the primary coil is, however, broken into in three separate places by Terminal No. 2, Fig. 76, which includes a certain number of turns and which is the one to be used when the line voltage is low. Terminal No. 3, Fig. 76, includes a few more turns and is used when the line voltage is normal. Terminal No. 4, Fig. 76, includes still a few more turns and represents the end of the primary coil, which is used when the line voltage is high.

Fig. 77 illustrates the external appearance of the A. C. Economizer as connected to the line and to the projection lamp.

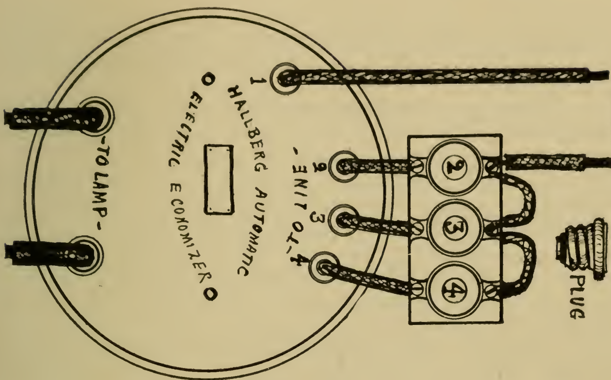

1
HALLBERG AUTOMATIC
ELECTRIC ECONOMIZER
TO LAMP
TO LINE
2
3
4
PLUG

Fig. 76.

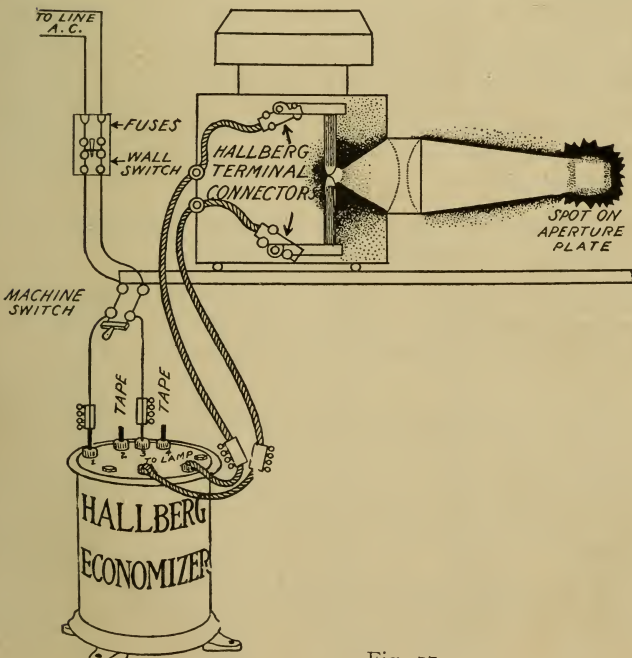

TO LINE
A.C.
FUSES
WALL
SWITCH
HALLBERG
TERMINAL
CONNECTORS
SPOT ON
APERTURE
PLATE
MACHINE
SWITCH
TAPE
TAPE
TO LAMP
HALLBERG
ECONOMIZER

Fig. 77.

The machine switch is always connected on the line side of the economizer. The asbestos covered cables from the lamp must be connected *directly* to the lamp leads extending from the economizer.

The "Hallberg" economizer is regularly furnished for voltages ranging from 100 to 120, or from 200 to 220, and may be constructed for 25, 33, 40, 50, 60 and 120 to 140 cycles.

On 110 volts, the economizer line wires are usually attached to Terminals 1 and 2 for any voltage from 100 to 105; on 1 and 3 for 110 volts, or to Terminals 1 and 4 if the line voltage should vary between 115 and 120. If the economizer is made for 220 volts, then the line wires are connected to 1 and 2 for 220 volts; on 1 and 3 for 210 volts, or to 1 and 4 for 220 volts. (See diagram, Fig. 77.)

Some operators desire varying candlepower at the arc to accommodate lighter, or more dense films. In a case of this kind, it is possible to simply install a 3-pole Edison main line cutout (with one single fuse plug), connected to the ecomonizer, as illustrated in Fig. 76. By simply putting the plug in Terminal No. 2, a heavy amperage is secured. Unscrew the plug, put it in No. 3 and a medium current is secured. For still less light, unscrew the plug and put it in Terminal No. 4. This arrangement is exceedingly simple, cheap and practical, and will never wear out or give trouble. The plug can be instantly changed from one terminal to the other, giving three degrees of amperes at the arc.

"HALLBERG" ALTERNATING CURRENT ECONOMIZER DATA

Line fuses required.	Line Voltage.	Line Amperes.	Line watts per hour.	Amperes at arc.
	Regular Type—30-40 *Amperes.*			
20	110	18	1,400	30-40
10	220	9	1,400	30-40
	Standard Type—45-55 *Amperes.*			
30	110	25	1,800	45-55
15	220	13	1,800	45-55
	Special Type—60-80 *Amperes.*			
40	110	35	2,200	60-80
20	220	18	2,200	60-80
	Search-Light Type—125-150 *Amperes.*			
80	110	75	4,200	125-150
40	220	35	4,200	125-150

The various "Hallberg" economizers, in accordance with the foregoing data, are intended for certain purposes, as follows:

The *Regular* type for stereopticon work and very light motion picture theater work, where the throw is short and the size of the picture is small, and where the performance does not run very long at a time.

The *Standard* type is the one recommended for every day motion picture performances. It delivers a powerful illumination at the arc and is good for all distances up to about 100 feet, and for pictures measuring as much as 18 feet wide.

The *Special* type of "Hallberg" economizer is made for those who desire a more than ordinarily powerful light with A. C. at the arc. It has been used with success for distances up to 130 feet, and for pictures measuring as much as 26 feet across.

The *Search-Light* type economizer was originally designed for Kinemacolor work, but it proved of such great value as a light producer that it is now offered to the regular motion picture trade as a means of producing the most perfect light which can be had with alternating current at the arc. It makes a brilliant white field, and when used with ¾-inch carbons, or possibly one-inch diameter, it is entirely practical, especially when the modern large lamphouses are employed, such as furnished by the manufacturers of all latest model machines.

The practical operating success of the "Hallberg" economizer depends upon a very few elements:

1—The voltage and cycles of the current must be proper for the economizer.

2—All connections, especially those between the economizer and the carbon jaws and also between the carbons and carbon jaws must be clean and perfect.

3—The asbestos covered cables must never be of smaller capacity than No. 6, and for the Special and Search-Light economizers, these cables should be No. 4 and No. 2, respectively.

ALTERNATING CURRENT COMPENSARC, TYPE A

This device is made by the Fort Wayne (Ind.) Electric Works, and is a self-contained device, requiring no auxiliary rheostat or other controlling mechanism. It should be placed near the projection machine, so that the switch is within convenient reach of the operator.

Before installing the compensarc examine the name-plate to see if the rating agrees with the cycles and line voltage of your current. Connect both wires from the operating circuit to the two terminals marked "line," and from the two terminals marked "lamp" connect the wires leading to the terminals of the projection machine lamp. As this is an alternating current device, there are no positive or negative wires.

Fig. 79 is a diagram of connections for the A. C. Compensarc. The primary or line wires should be fused to about half the maximum current at the lamp. This would ordinarily require about a 30 ampere fuse. This device is adjustable in three steps, which three steps have been found to meet the general service conditions. When the switch on the compensarc is open no current flows through the lamp. The operator can therefore freely handle carbons and make any adjustments required without opening the line switch.

Fig. 80 shows the slate top of the A. C. Compensarc and the switchboards. Throwing the switch-blade in contact with the first clip of switch, Fig. 80 gives an adjustment so that with the carbons separated about 3-16 of an inch the current supply is approximately 30 amperes. In contact with second clip of switch the adjustment

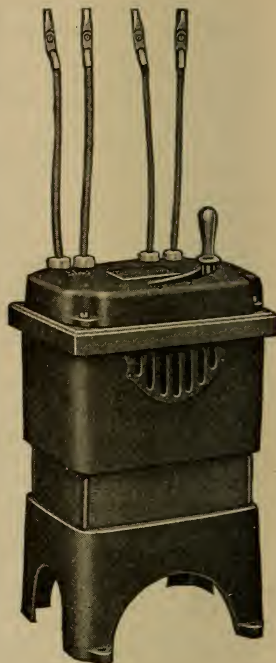


Fig. 78.

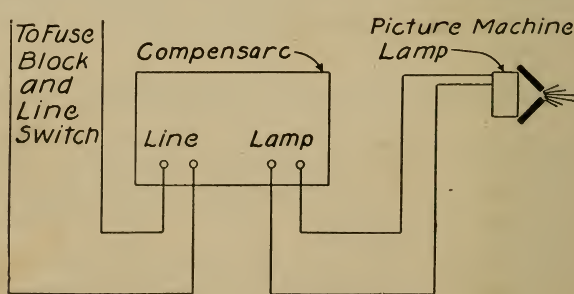


Fig. 79.

changes so that approximately 40 amperes flow through the arc. Throwing the switch blade over to the third clip of switch allows approximately 60 amperes to flow through the lamp. The best results are obtained by using cored carbons 5/8 of an inch in diameter.

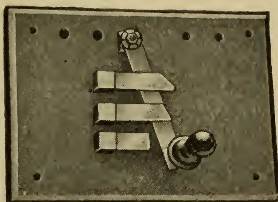


Fig. 80.

In order to determine if your Compensarc is in good condition on all three steps; first, start the arc on any one of the steps, then jump the switch quickly to the other two steps in succession, watching the light. There should be an appreciable difference in the light, which you can very readily detect in trying this—one or two times. If you think the compensarc is heating up too much, do not attempt to determine the temperature with your hand, but put a thermometer on its hottest part for about five or ten minues, and then take a reading of the thermometer. Temperature rise should never exceed 40 degrees C. or 72 degrees F., above the temperature of the surrounding atmosphere.

If you will observe the following points you will be pretty sure to get good results:

1—Make sure that the two leads marked "lamp" are connected directly to the lamp.

2—The other two cables coming from the compensarc should be connected to the line directly.

3—Never connect any resistances up with the compensarc, on either the lamp or the line side. The compensarc is intended to cut out all resistances. Be sure the line voltage and frequency (cycles) agree approximately with the line voltage and frequency marked on the name-plate on the Compensarc.

4—Be sure that all connections from the line to the lamp terminals are tightened up, and see that the switch has not been damaged in shipment.

5—Do not try to use any more current in the lamp than necessary for the light required. A ⅝-inch carbon will operate very satisfactorily on 40 amperes with about a 3-16 inch separation. Very much more current than this will tend to produce noise at the arc.

THE FORMOSTAT

The formostat, which is widely used and well-known on the Pacific Coast, and somewhat known throughout the Middle West, is of the auto type of transformer. Its ratio is two to one for 110 volt current, and 4 to 1 in the 220 volt type—that is to say, one ampere taken from 110 volt line becomes two on the secondary, while one ampere taken from the 220 volt line becomes four on the secondary. Its range of adjustment is from 30 to 65 amperes, and its construction is quite simple, there being two wires for the line and two for the lamp. These leads are marked with paper tags, when the formostat is purchased. In case these tags are absent the two large leads should be connected to the lamp and the two smaller ones to the feed wires. The adjustment is made in divisions of about 4 amperes and without in any way disturbing the arc.

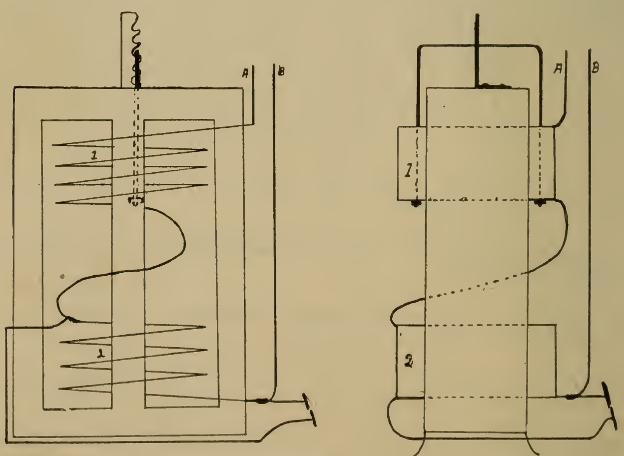


Fig 81.

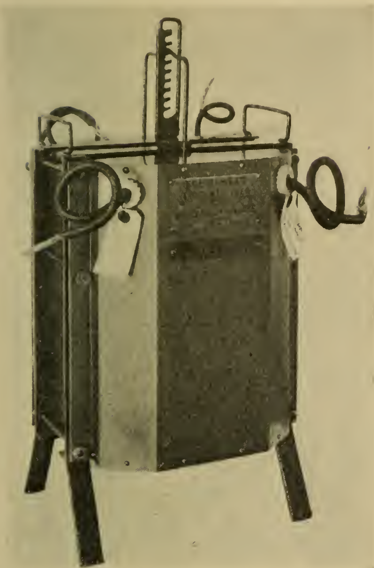


Fig. 82.

In Fig. 81 we see a sectional front and side view, A and B being the line wires and 1 and 2 the coils. The regulation of amperage is secured by raising or lowering the top coil.

In Fig. 82 we have a view of the formostat. At the top we see a notched rack upon which hangs a wire loop; from this loop is suspended coil 1, Fig. 81. By lowering coil 1, or in other words, dropping the wire loop to a lower notch in the rack the amperage is increased, or by raising it the amperage is lowered. The winding on the 110 volt formostat is of No. 5 wire, and as the instrument is of the auto type this is equivalent to two No. 5 wires in parallel, so that as a matter of fact, the No. 5 wire has to carry 32½ amperes. In the 220 volt type the winding is of No. 4 and No. 8 wires, and at full load the No. 4 carries 43 and the No. 8, 17 amperes, respectively. A 110 volt formostat works well on any voltage from 105 to 125, and the 220 volt machine operates successfully at from 210 to 240 volts. The makers recommend that the formostat be placed on the floor under the lamphouse. Connect the wires marked "line," which are the smaller of the four wires, to the line through 30 ampere fuse and switch. Connect the two leads marked "lamp" directly to the lamp. The formostat makers recommend that there be no switch between the formostat and the lamp, but that it be placed on the line side. This, however, I cannot agree with in the case of 220 volt current, since the tendency to arcing would be much greater even though amperage be but half of that of the secondary. All wire connections should be soldered, unless some good type of wire connector is used; see page 30.

Wiring Diagrams for the Formostat.—Fig. 83, No. 1, shows the connections used with the regular 110 volt formostat worked on two lamps. No. 2 shows connections used with regular 110 volt formostat for three lamps. That is to say, a motion picture arc and a dissolver. No. 3 shows connections used with special 220 volt formostat for two lamps, and No. 4 shows connections used with special 220 volt formostat for three lamps.

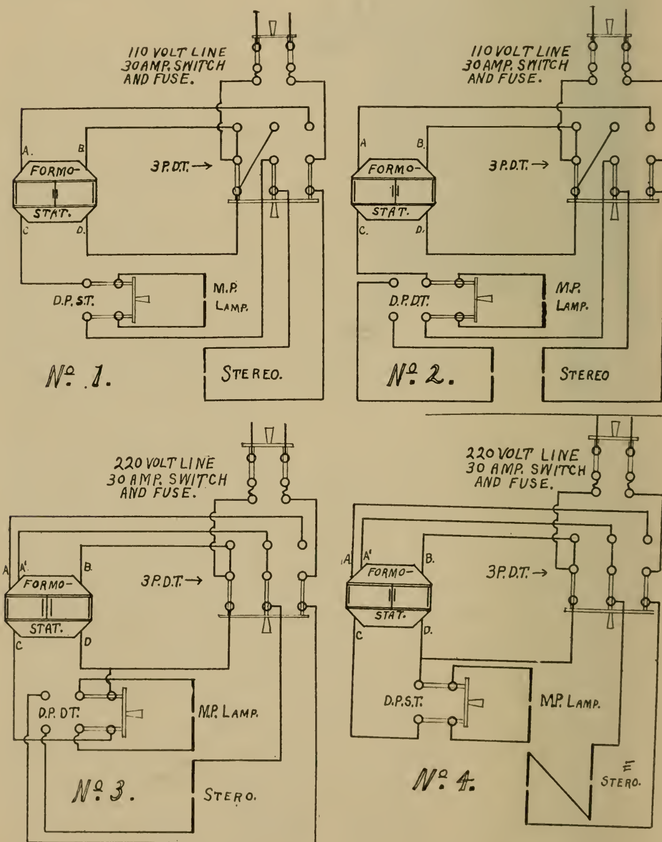


Fig. 83.

The tags on the wires are marked A, B, C and D, in 110 volt type, and A A prime, B, C, D, on the 220 volt tags. The tags were not marked until this year. If it is desired to use the 110 volt formostat with connections as per No. 1, or 2, Fig. 83, the leads will first have to be marked by testing between the line and lamp leads with 110 volt lamp. Between two of these wires will be found no voltage and these wires are line A and lamp C, therefore the two remaining are line B and lamp D. This test must, of course, be made with the current on. If it is desired to use connections No. 3 or No. 4, Fig. 83, with the 220 volt formostat, put out before the beginning of 1912, the wires will have to be changed, and this the manufacturer will do, free of charge. The change cannot be made outside of the manufacturer's shop, and should not be attempted.

THE PREDDEY ECONOMIZER

This device is used in many houses in the West and is an open core choke, or reactance coil, designed for use on circuits of from 90 to 140 volts and 60 to 133 cycles.

The general appearance of the device and its wiring diagram is illustrated in Fig. 84.

Regulation is effected by connecting to the contacts, shown

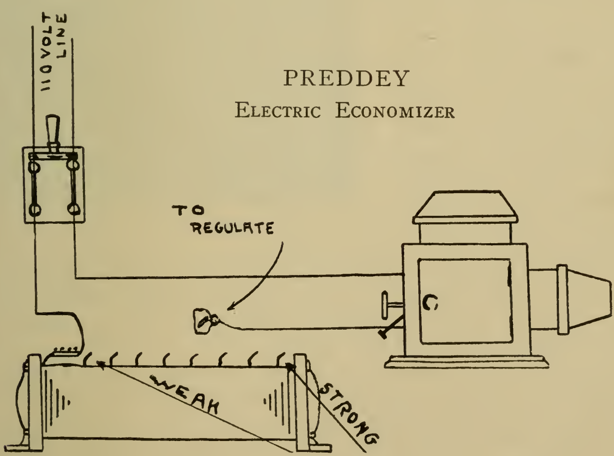


Fig. 84.

in Fig. 84. There are eleven of these, each delivering a different number of amperes, beginning at the lowest and gradually increasing, in four ampere divisions, according to the table below:

	Contact										
Volts.	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th	11th
100	27	31	35	39	43	47	51	55	59	63	67
105	31	35	39	43	47	51	55	59	63	67	71
110	35	39	43	47	51	55	59	63	67	71	75
115	39	43	47	51	55	59	63	67	71	75	79
120	43	47	51	55	59	63	67	71	75	79	83

The Preddey Economizer is 21 inches in length by 6 inches high by 6 inches wide. Its weight is 85 pounds.

To operate a dissolving stereopticon, the lamps must be connected in series, as illustrated on page —, and the economizer must then be regulated to deliver a greater number of amperes than would be necessary if only one lamp were in use. The principle of operation is as follows: The A. C. projection arc, while its voltage varies somewhat, averages perhaps a little less than 35 volts when operating at its best—let us say between 30 and 35 volts. It therefore follows that some device must be used to reduce the pressure from 110, or whatever voltage the lines carry, to the arc voltage. This may be accomplished in several ways, one of which is by the use of the Preddey reactance, or choke coil. In this device the current is passed through a coil of very heavy copper wire (No. 4). This wire is wound around a laminated iron core, made up of sheet metal. When current passes through the wire coil it sets up, through the medium of the core, a series of electro-magnetic waves, commonly known as "magnetic kick," which tend to oppose the passage of the current, and in consequence the voltage falls to the required pressure, which same may be varied by connecting to different contacts, each one of which cuts out, or cuts in a certain number of additional turns of wire in the coil. The makers of the Preddey Economizer recommend that 5/8 cored carbons be used with their apparatus, and that they be so set that the top carbon will be in line with and directly above the lower carbon, using hard carbons where the device is delivering above 55 amperes, and soft carbons below this point.

To connect the economizer, fasten it to the wall in a vertical position. It should be placed within convenient reach of the operator and with the name plate on top. Do not fasten to an iron-clad room without first attaching blocks of wood, covered with asbestos. Never fasten the economizer directly to the iron. Connect the regulating contact with the contact nearest the name plate and gradually move it backward, attaching to other successive contacts, until the desired current strength is obtained. Do not tighten the connector screw with pliers.

POWER'S INDUCTOR

Power's Inductor, Fig. 85, is of the double coil type, illustrated in C, Fig. 71. The coils are protected by means of cast iron sides and fiber top and ends. There are electrical reasons why the fiber is used instead of metal, to cover the top and two ends of the device. On one side of the inductor you will see two wires coming through the casting marked "line." This means that the two leads from the main operating room switch are to be connected to these two wires. On the opposite side will be seen two other holes through which come A B, wires, with the word "lamp" in the casting underneath. The leads from the lamp are to be attached to these two wires. That is all there is to connecting up the inductor. On the face of the casting of one side are the words "high," "medium," and "low," with an indicator, C, pointing to them, the latter being controlled by the large knob D. This knob controls an ordinary single pole three-contact knife switch, located behind the casting, and the amperage is respectively high, medium, or low, according to which contact the switch is on. When indicator C is in the notch indicated by arrows, the switch is in position to make the best possible electrical contact. The operating switch and fuses should always be inserted on the line side—never between the inductor and the lamp. The inductor is designed for a maximum of 65 amperes on "high," 54 on "medium," and 45 on "low," when used on 110 or

Fig. 85.

220 volts, it being of course understood that for 110 volt current you must have a 110 volt inductor, and for 220 volt current you must have a 220 volt inductor. The device may, however, be used on pressure ranging from 10 per cent below to 10 per cent. above the voltage for which it is rated, but in the one case there will be a corresponding increase and in the other a corresponding decrease in amperage as per its rated capacity.

The inductor is designed for a maximum temperature rise of 50 degrees, Fahrenheit, above the surrounding atmosphere, and will usually operate at a temperature rise of not to exceed 30 degrees. The inductor weighs about 104 pounds; is 19 inches high and occupies 12 x 14 inches floor space. Its manufacturers claim an efficiency of 97 per cent.

Power's Little Giant.—Power's Little Giant has the same electrical action, same mechanical design as has the inductor before described, but it is not provided with a case and has no adjustment switch. Different amperage is obtained by changing the connections. The two leads not in use should have their ends tapped over so as to have their ends unexposed. The secondary leads are marked "lamp" and the lamp leads should be connected directly thereto. Switch and fuses, being on the line side, where an adjustment of the amperage at the arc is not efficient.

The Mercury Arc Rectifier

THE Mercury Arc Rectifier, designed and manufactured by the General Electric Company of Schenectady, N. Y., is a device for changing alternating current (A. C.), to direct current (D. C.). The one described in the following pages is that particularly designed for furnishing direct current to carbon arc lamps, such as are used for moving picture machines, stereopticons, spot and flood lamps, and for other similar purposes. In order that the operator may thoroughly understand the rectifier, the principal parts are first described:

Rectifier Tube.—The rectifier tube is a glass vessel of a shape shown in Fig. 85½. It has four terminals or electrodes, two of graphite (anodes A—A', Fig. 87, and two of mercury (the cathode "B" and the starting anode "C"). In the manufacture of these tubes the air is entirely pumped out by means of a vacuum pump, leaving as complete a vacuum as possible, which is necessary to make the rectifier operate.

Anode.—The positive pole. The path by which current passes out and enters an electrolyte (mercury vapor in this case), on its way to the other pole.

Cathode.—The point at which current passes out of an electrolyte. The negative pole, with respect to the mercury arc; positive to the moving picture arc.

Main Reactance. Fig. 86.—The main reactance is something like a moving picture transformer, but for reasons unnecessary to mention, it must be wound with more wire and have a larger iron core than a moving picture transformer of the same capacity. This main reactance is used for three distinct purposes, as follows:

1st.—It lowers the alternating voltage to the right value to apply to the anodes of the tube to give the proper direct voltage for the projection arc.

2d.—It makes a neutral point between the alternating current lines which is used as one side of the direct current line—the negative.

3d.—By its reactance it keeps the rectifier tube in operation while the alternating current is at and near zero.

The Regulating Reactance, 21, Fig. 88, is simply a choke coil with taps taken off at certain points along the winding so that the alternating current can be choked back or reduced to give the desired direct current in the projection arc. It gives very much the same effect as a resistance (rheostat) would, but with practically no waste of current. By using the various taps on the reactance almost any D. C. amperage can be obtained, within the capacity of the rectifier.

Shaking Magnet.—The shaking magnet, Fig. 86, is an electro-magnet used to rock the tube, which is necessary in starting, as will be explained later under "Theory."

Relay.—The relay, Fig. 86, is another electro-magnet with two contacts under its glass cover at the top. These open the shaking coil circuit as soon as the rectifier tube starts.

Theory.—The mathematical demonstration of the theory of the Mercury Arc Rectifier is rather complicated, but I will try to explain in as few words as possible the reasons for its action.

Fig. 87 shows a very elementary diagram of the rectifier connections, with all the different accessories, such as shaking magnet, relay, etc., omitted, leaving only the principal parts, rectifier tube, main reactance, and regulating reactance, all shown diagrammatically, and with no reference to position on the panel with relation to one another. Each anode of the rectifier tube, it will be seen, is connected to a separate side of the alternating current supply; also through one-half of the main reactance to the negative side of the arc lamp.

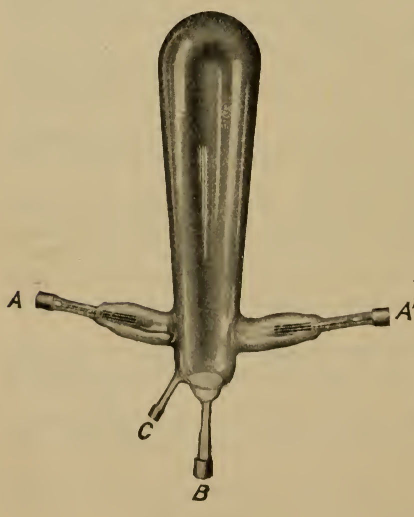


Fig. 85½.

The cathode connects to the positive side or upper carbon of the arc lamp. The small starting anode "C" is connected through the starting anode resistance to one side of the alternating current circuit, and is

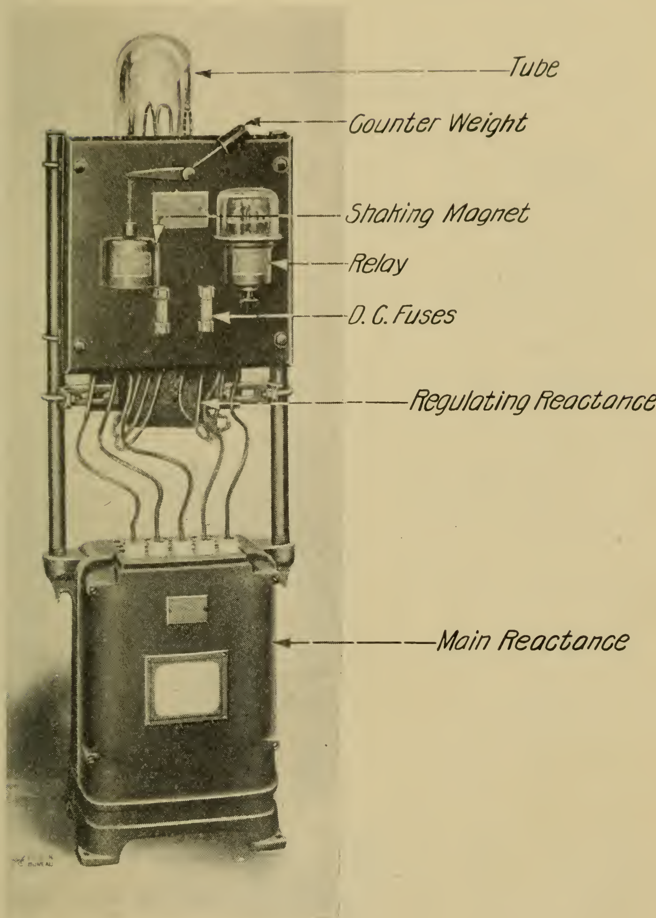


Fig. 86.

used for starting the mercury arc in the tube. When the rectifier tube is rocked, the mercury in B and C connects, forming a mercury bridge between the cathode "B" and the starting anode "C," and a slight arc is formed. This starts what is known as the

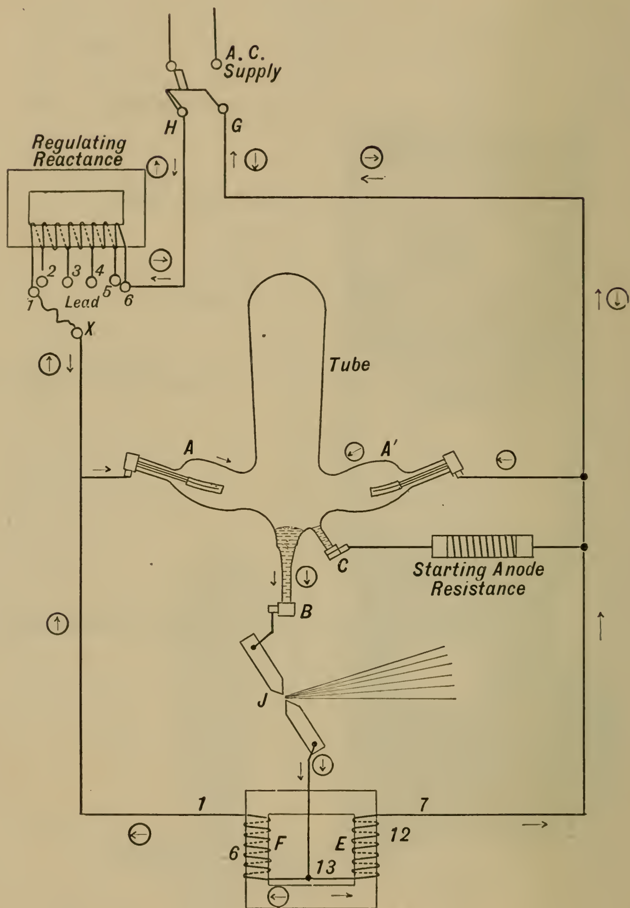


Fig. 87.

"excitation" of the tube, and the cathode begins supplying ionized mercury vapor, the bridge between B and C having broken again. This condition of excitation can be kept up only as long as there is current flowing toward cathode B. If the direction of current supply is reversed so that the former negative electrode or cathode, becomes positive as occurs when the alternating current circuit reverses its direction, the current ceases to flow, since in order to flow in the opposite direction, it would require the formation of a new cathode; or, in other words, changing an anode into a cathode, which can be accomplished only by special means. Therefore, in the rectifier tube, the current must always flow toward cathode B, which is kept in a state of "excitation" by the current itself.

Such a tube would cease to operate on alternating voltage after one-half of a cycle, were not some means provided to maintain the flow of current continuously toward cathode B.

The maintenance of the current flow is accomplished by the main reactance. As the current alternates, first one anode and then the other becomes positive, the current flowing from the positive anode through the mercury vapor, toward the cathode, thence through the moving picture lamp, and back through one-half of the main reactance to the opposite side of the alternating current supply circuit. As the current flows through the main reactance it charges it, and while the value of the alternating wave is decreasing, reversing and increasing, the reactance discharges, thus maintaining the mercury arc until the voltage reaches the value required to maintain the current against the resistance of the arc lamp. In this way a true direct current is produced with very little loss in transformation.

To get an idea of the operation of the Mercury Arc Rectifier, assume that the instant when the terminal "H," Fig. 87, of the A. C. supply circuit is positive "+" the anode "A" is then positive, and the current is free to flow through the mercury vapor from "A" to "B." Following the direction of the arrows still further, the current passes through the arc lamp "J," through one-half of the reactance coil "E," and back to the negative terminal "G," of the A. C. circuit. When the alternating voltage falls below a value sufficient to maintain the mercury arc against the combined resistance of the mercury arc, in the tube, and the arc lamp, the reactance coil "E," which heretofore has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the mercury arc in the rectifier tube until the alternating voltage has passed through zero, reversed and built up to such a value as to cause the anode "A" to have a sufficient positive voltage to start the arc between it and the cathode "B." The discharge circuit of the reactance coil "E" is now through the mercury arc "A′ B" instead of through its former circuit. Consequently the arc "A′ B" is now supplied with current, partly from the alternating circuit, and partly from the reactance coil "E." The new circuit from the main A. C. circuit is indicated by the arrows enclosed in circles.

In the above description of the action of the rectifier, the regulating reactance has been disregarded as it really has no part in the rectification of the alternating current, but simply serves to regulate the pressure of the alternating current, which affects the direct current.

Installation.—The rectifier will be received in two crates, one containing the panel, reactances, etc., all assembled; the other the rectifier tubes. (Only one tube is included with the rectifier, but it is advisable to have one extra one on hand. There is no deterioration in a tube not used.)

First, uncrate the panel and stand it in its permanent position, and, if convenient, screw it down to the floor, although the main reactance on which the panel is mounted is plenty heavy enough to make it difficult to tip the panel over, even if it is not screwed down. The rectifier may be installed in any fairly clean, dry place; for example, in the operating room; in a glass show case in the lobby, where the greenish-blue light attracts considerable attention, thus providing a little free advertising for the theater; or the rectifier may be set up in a window near the street level with the same effect. Don't put it down in the cellar and forget about it. It is much better to locate it where it can be looked over once in a while.

After the location is decided, run the A. C. supply wires from a line switch to the connection wires on the panel marked A. C. (Use No 6 B. & S. wire.) Then run lines (No. 6 B. & S.) from the connection wires on rectifier marked "D. C." to machine switch, if there is one; if not, to the lamp. Be sure the wire marked "+" on the rectifier is connected to the upper carbon on the moving picture lamp, and the wire marked "—" to the lower carbon.

The proper connections of the main reactance must next be made. The connections depend on the voltage of the alternating current circuit and should be as indicated further on (Fig. 88).

When the connections of the main reactance are made, the current in the arc lamp must be adjusted by means of the regulating reactance. Before doing this is it best to borrow a good ammeter (one can generally be obtained from the electric light company). An ammeter is a very desirable instrument to have continually connected in the lamp circuit, as it always indicates the current in the arc and shows if the lamp is drawing more than it should. It also is a good indicator to tell when to feed

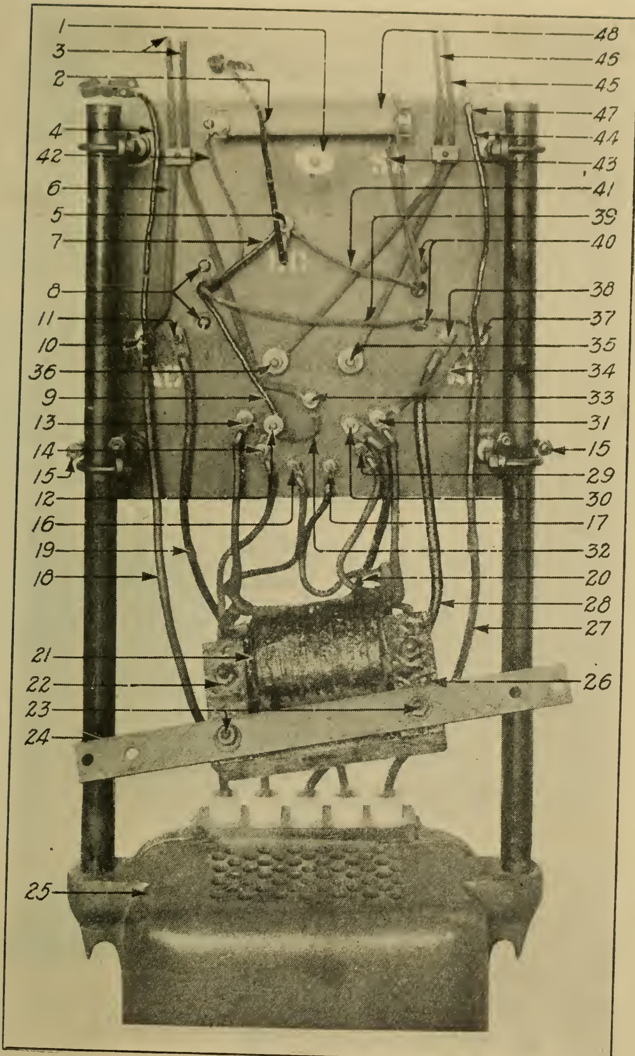


Fig. 88. For description see page 181.

the lamp, when the current falls it indicates that it is time to feed the carbons.

An entirely reliable ammeter can be purchased for from $15.00 to $20.00. Connect in the ammeter by opening one side of the circuit between the rectifier and the arc lamp, and connect in the ammeter, as shown in Fig. 33, page 91. Now connect the regulating reactance for trial.

In Fig. 88 connections for 110 and 220 volts are made as follows:

If A. C. is about 220 volts, 60 cycles, connect lead 32, Fig. 88, to stud 13, as shown in Fig. 88, to which also is connected a lead from the regulating reactance.

If A. C. is about 110 volts, 60 cycles, connect the lead 32 to stud 17, Fig. 88. If the frequency is 25 cycles, connect to stud 14, and if it is 40 cycles, connect to stud 16.

The connections given above indicate approximately where the lead 32 should be set and, if carefully followed, will not give too much current for the trial, and after the tube is once tried the taps may be changed—to increase the D. C. amperes move the lead 32 to the next higher numbered tap on the regulating reactance, as from number 13 to number 14, and to decrease the D. C. amperes, connect the lead 32 to the next lower stud, as from 17 to number 16.

The rectifier tube may now be removed from the crate by taking out the screws at the ends, and taking hold of the box by the ends, remove the upper half, which will slip off easily. With a screwdriver remove the braces around one tube and take the tube carefully from the crate without turning it over.

Now take hold of the tube, as shown in Fig. 88½, turning it over, bringing the large bulb toward the top, being care-

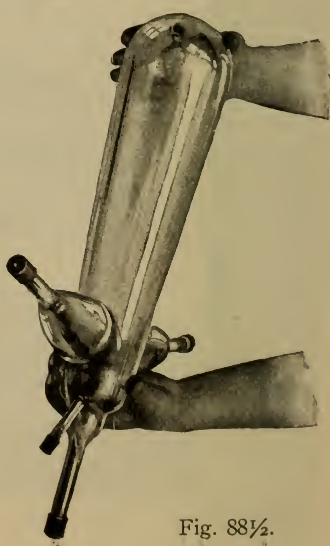


Fig. 88½.

ful that the mercury does not flow into the anode arms, but flows straight and rather slowly to the cathode "B."

If, after the mercury is all in the cathode receptacle, there are any bubbles (air) in the mercury column, it indicates that there is air in the tube and it has probably been damaged in shipment. If no air bubbles show, the tube is all right.

In either of these cases the tube should be carefully placed in the holder on the back of the panel, first putting the small part of the large bulb in the upper clip and slowly lowering the tube until the anode arms rest firmly in the lower clips. Now connect the tube by means of the spring clips.

All is now ready to start the rectifier. Close the A. C. line switch and the lamp switch, if there is one, then close the lamp carbons together. This will cause the shaking magnet to rock the tube, which will start in a few shakes.

If the tube fails to start and forms a mercury-oxide (black scum), between the starting anode and the cathode, the vacuum in the tube is probably gone and you should write to the nearest office of the General Electric Company, or to the agent from whom you bought the rectifier, giving the numbers on the tube and telling them how it acted.

When the tube is working it gives off a greenish-blue light. As soon as the tube starts the arc lamp carbons should be separated and the arc drawn out to about ¼ to ⅜ of an inch. If the ammeter indicates too low current or the tube goes out as soon as the carbons are separated, the current may be increased by changing the tap on the regulating reactance, as previously described. Try the arc again and it will probably be all right. If just the right current is not obtained, it is possible to get other ampere values by connecting lead 34, Fig. 88, to stud 29, on the regulating reactance instead of stud 31, and the lead 32, on stud 16, for example, instead of stud 17. In fact, it is possible to connect any part of the regulating reactance in, provided adjoining sections are used.

This makes it possible and practical to use the G. E. Mercury Arc Rectifier under a great variety of conditions. In this connection it is interesting to know that this type of rectifier can be used on 25, 40, 60, or 125 cycle circuits by simply changing the starting anode resistance at a cost of about thirty-five cents and in about one minute's time. This is not true of most other economizers and is a point worth remembering as the circuit on which the rectifier is operating may be changed sometime, or the rectifier may be moved to another town, where the frequency is different.

Some Suggestions.—Don't be afraid of the rectifier. It may look a little more complicated than the choke coil or rheostat, which you have been using, but when you get acquainted with it you'll see how simple it really is.

If the shaking magnet doesn't work freely, put a little oil on the tube holder bearing and adjust the counterweight so the tube-holder balances better.

Keep the contacts on the relay clean. If the tube won't shake, clean the relay contacts with sand or emery paper.

The tube may start a little hard the first time each day if in a very cold place (10 degrees above zero or lower). There is no harm, other than the hard starting, from installing the tube in a cold place. It must, however, be thoroughly protected from rain or snow.

Do not try to get more than the rated capacity out of the rectifier, as indicated by the name plate on the panel. A thirty ampere rectifier is good for thirty-one or thirty-two amperes, but don't try to get more. If you want forty amperes, buy a forty ampere rectifier. Tubes are guaranteed to run on an average of six hundred actual working hours under normal conditions; that is, at or below the amperes stamped on the panel name-plate. Many tubes have operated as long as 4,000 or 5,000 hours. A tube which is not properly handled as to overload will not last as long as a tube carefully handled. Don't keep the carbons of your arc lamp together after the tube starts, as that means high current on the tube and very likely shorter life for the tube.

After the tube has given out it is of no value to the manufacturers, but you may be able to get a little money for the platinum, and possibly the mercury, from a druggist or scrap dealer.

If you have the right current on your arc lamp and don't get a good light, there is probably something wrong with your carbons or you haven't them set right. Remember for D. C. you should use a 5/8-inch cored carbon for the upper, and a 1/2-inch solid carbon for the lower. See page — for the proper adjustments for D. C. If carbons are too hard they are liable to flare and sputter.

Efficiency.—The efficiency of the rectifier should not be compared with that of the ordinary economizer for A. C. circuits, as the rectifier not only controls and regulates the current in the arc, but it also changes A. C. to D. C., which, every operator knows, gives a brighter and steadier light on the screen than A. C. The efficiency of the rectifier is about 71 or 72 per cent. This means that it takes about 2 1-10 kilowatts from the line to deliver 1 1/2 kilowatts to the lamp. From a D. C. circuit with a rheostat in series with the arc, 3 3-10 kilowatts would e required to deliver the same amount to the lamp. So, considering all that the rectifier does, it is a very efficient device.

Description of Back View of Rectifier (Fig. 88) with regulating reactance coil lowered to show all the parts:

1—Clamp for holding wire part of tube-holder.
2—Lead on end of which is clip to connect cathode on tube.
3—Wires to which should be connected A. C. supply.
4—Lead to clip which should be connected to left-hand anode on rectifier tube.
5—Expansion bolt and nut.
6—Lead "Z."
7—Lead to relay coil in relay on front of panel.
8—Screws supporting relay on front of panel.
9—Lead from relay to stud holding lower fuse clip.
10—Stud to which is connected 6, when rectifier is used with 220 volt A. C. supply.
11—Lead 6 should be connected to stud 11 instead of 10 when operating on 110 volts.
12—Screw and nut holding lower fuse clip on front of panel.
13—Stud to which is connected lead (No. 6 marked on lead), from regulating reactance coil.
14—Stud to which is connected (No. 5 on lead) lead to regulating reactance coil.
15—Yoke for holding strap mounting regulating reactance.
16—Stud connecting lead (No. 4 on lead) to regulating reactance.
17—Stud connecting lead (No. 3 on lead) to regulating reactance.
18—Lead (No. 7 on lead) from main reactance.
19—Lead (No. 12 on lead) from main reactance.
20—Lead (No. 13 on lead) from main reactance to lower left fuse clip.
21—Regulating reactance coil.
22—Nut for holding laminations of regulating reactance core together.
23—Supporting bolts for regulating reactance.
24—Supporting iron strap for regulating reactance; attaches to yoke 15.
25—Top of main reactance.
26—Regulating reactance core.
27—Lead (No. 1 on lead) from main reactance.
28—Lead (No. 6 on lead) from main reactance.
29—Stud to which is connected lead (No. 2 on lead) to regulating reactance.
30—Stud of lower left-hand fuse clip connecting lead (No. 13 on lead) to fuse.

31—Stud connecting lead (No. 1 on lead) to regulating reactance.
32—Lead "X."
33—Expansion bolt and nut to which is connected lead "X" and one side of A. C. line wire from 3.
34—Lead "Y."
35—Stud and nut to upper right-hand fuse clip.
36—Stud and nut to upper left-hand fuse clip.
37—Stud—Connect lead 34 to this stud when operating on 220 volt A. C.
38—Stud—Connect lead 34 to this stud when operating on 110 volt A. C.
39—Lead from 37 to one relay contact.
40—Screws supporting shaking magnet on front of panel.
41*-Red lead from shaking coil.
42—Lead from relay contact to one side of starting anode resistance.
43*-Black lead from opposite side of starting anode resistance to relay coil.
44—Lead to which is connected clip for connection to right-hand anode on rectifier tube.
45—Negative D. C. wire from rectifier which should be connected to lower carbon on arc lamp.
46—Postive D. C. wire from rectifier which should be connected to upper carbon on arc lamp.
47*-Green lead from shaking magnet coil connected to small clip for connection to starting anode on rectifier tube.
48—Starting anode resistance.

* Leads are of different colors to aid factory in connecting.

Motor Generator Sets

DIRECT CURRENT NON-RESISTANCE D. C. TO D. C.

THE Hallberg D. C. Economizer.—A direct current projector arc lamp requires between 45 and 55 volts drop across the arc for best results. It is safe to say that the average voltage drop across a D. C. projector arc is 48 volts.

As a rule electric power companies do not supply current for use in theaters at a lower potential than 100 volts, and the average voltage is 110. In some localities the lowest voltage obtainable is 220, and again in a few places the only current available on which to operate a motion picture arc lamp is supplied at over 500 volts pressure.

Taking for granted that the average arc voltage required is 48, and that the minimum supply voltage is 110, it is evident that there is a loss of 60 volts, usually consumed by a rheostat connected in series with the line and the arc. If we consider a 30 ampere arc, this loss equals 30 amperes times 60 volts, or 1,800 watts, which is the energy that is thus wasted in heat by the 30 ampere rheostat on a 110 volt D. C. circuit. One would think that the easy remedy would then be to provide a dynamo which would deliver 50 volts to the arc, thereby doing away with the losses, but unfortunately such machines are comparatively expensive, and besides would not operate the arc satisfactorily. Experience proves that about 60 volts is the lowest practical limit with ordinary dynamos or generators, which must on that account be used together with a small rheostat connected in series with the arc, which introduces more loss in addition to the losses in the generator, and the motor necessary to drive it, so that very little economy is effected, and it further does not pay to install an ordinary motor generator for the operation of projector arc-lamps, at least when the supply is D. C.

With 220 volts supplied by the electric company, the loss in the rheostat is much greater, representing the difference between the 50 and 220, or 170 volts, times 30 amperes, which equals over five kilowatts. With 550 volts the loss is tremendous, representing the difference between 50 and 550, which equals 500 volts times 30 amperes, or 15 kilowatts.

With these figures before the operator, showing a loss on the direct current rheostat of 1.8 k.w. per hour on 110 volts; 5 k.w. on a 220 volt line, and 15 k.w. on a 550 volt line, it instantly becomes highly desirable to stop such enormous waste. It is impossible to eliminate all of it, because of the fact that work cannot be performed without waste and because of the fact that with the ordinary dynamo it is necessary to successful operation that the arc have a steadying resistance or ballast. Without this, the arc would take all of the current the line wires could supply, just as an engine would "run away" without the steadying influence of a governor.

In the past, in order to secure this ballast, or steadying effect, the rheostat has been necessary, but there has now been developed a type of generator which has proven successful and which does away with the necessity for rheostatic resistance in series with the arc. These machines, which are in fact a dynamo of peculiar construction, driven by a D. C. motor, generate D. C. at the arc voltage and automatically supply the voltage and amperage required without any resistance.

Field rheostats involve no appreciable waste. Therefore, the only loss is that caused by mechanical and electrical friction in the motor and generator. This loss may range from 20 to 35 per cent., according to electrical efficiency of the motor and generator, and the mechanical excellence of construction. It will probably average 25 to 30 per cent.

Two machines of this kind, which are a demonstrated and undoubted success, are the Hallberg Automatic Direct Current Economizer, made by Mr. J. H. Hallberg, New York City, and the "D. C. Compensarc," made by the Fort Wayne Electric Works. Fort Wayne, Indiana. These machines dispense entirely with the rheostat, and can be made for any voltage or amperage.

HALLBERG DIRECT CURRENT ECONOMIZER DATA

Line Input				Output at Arc				
Line Fuses Required.	Line Volts.	Line Amperes.	Line Watts.	Arc Voltage.	Arc Amperes.	Arc Watts.	Watts Loss.	Efficiency.
20 A	110	17	1,870	50-55	30	1,650	220	88%
10 A	220	10	2,200	50-55	30-35	1,650	550	75%
5 A	550	4	2,200	50-55	30-35	1,650	550	75%

The foregoing table is clear and explicit. It sets forth the size fuses required for the different line voltages; also the number of amperes taken from the line, as well as the number of watts per hour required from the line to produce at 50 to 55 volts, 30 to 35 amperes at the arc. By dividing the watts produced at the arc by the input in watts from the line, the efficiency figures for the economizer have been obtained. They represent the claim of the manufacturer, for which the author cannot vouch, though they may be correct.

Fig. 89 illustrates the general make-up of the 110 volt type of economizer, which, while being constructed along the lines of a motor generator, is in the strict sense of the word only in part

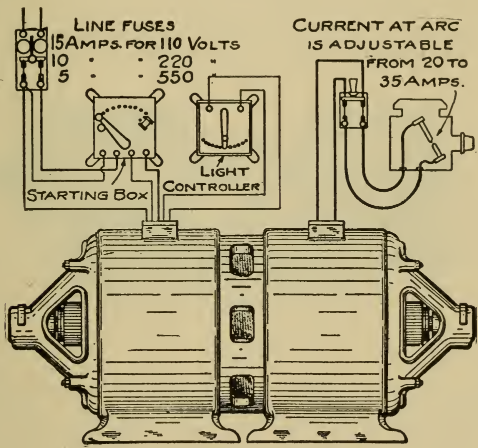


Fig. 89.

a motor generator. The principle involved is original with Mr. Hallberg and permits the use of a smaller and more efficient motor and generator than would be possible were the apparatus a straight motor generator set. The 110 volt outfit is provided with an automatic starting box and light controller by means of which the operator can vary the amperes at the arc anywhere from 20 to 30, on the 25 ampere size; from 30 to 40 amperes on the 35 ampere size, and from 40 to 60 on the 50 ampere size. It is, of course, possible to secure lower ampere output than specified as a minimum with any of the above machines, by the use of special light controllers, which can be furnished upon request.

Fig. 90 illustrates the Hallberg D. C. economizer as made for voltages ranging from 200 to 750. This outfit is a straight motor generator set, in which, however, the generator is of special construction delivering a steady ampere flow to the arc without the use of a rheostat. The 200 to 750 volt outfit is also furnished complete with automatic starter and light controller, and besides this outfit has a pulley coupling between the motor and generator on which, in special cases, a belt may be placed for driving the economizer by means of an engine, which would make the economizer operate a motion picture arc just as it does when driven from an electric circuit, and at the same time from the high voltage side current can be taken for driving fan motors, or a limited number of lamps. This is an important feature and is of considerable value to an exhibitor who might have occasion to move the economizer from one place to another.

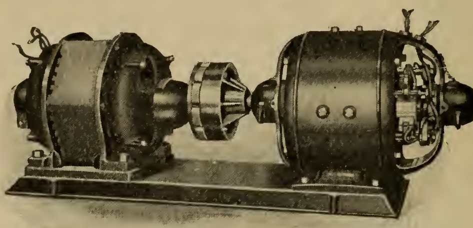


Fig. 90.

Another feature of construction is that the low voltage side of the economizer is a separate unit which can be run as an ordinary dynamo by an engine ranging from 3 to 6 horsepower in capacity for the operation of a motion picture arc. The other half of the machine, representing the high voltage side, is an ordinary electric motor which can be taken off its base in a few minutes' time and used as a regular electric motor, together with its automatic starter. These are points of economy which represent certain advantages to the purchaser of this class of apparatus. It is not practical to give wiring diagrams, showing the connections for these machines, because they vary for different voltages and currents, and as these machines are generally built to specifications to suit the individual operator or manager, it is best to depend upon the blue print and diagram of connections which accompany the shipment, and if the instructions should be lost, another set can be readily obtained at the office of the manufacturer.

INSTRUCTIONS FOR SETTING AND OPERATING

1. UNPACKING AND SETTING UP.—The machine should be unpacked carefully and installed in a cool, dry place where it will be free from dust and easily accessible for inspection and

care of brushes and oiling. If the operating room is large enough the machine can, of course, be installed there, which is preferable, other things being equal.

2. CONNECTIONS.—All connections should be made as shown on the wiring diagram sent with each machine. They must be clean and tight. Fuses should not have a higher capacity than that given on the diagram.

3. BRUSH TENSION.—After the machine has been properly set and connected, rotate the armature by hand and examine each and every carbon brush to make sure that it moves freely, without the slightest friction in the brush holder which guides it. Make sure that the flexible copper cable, or pigtail, as it is called, is properly clamped by the screw in the brush-holder casting, provided for that purpose. When the brush is in proper condition and moves freely in the holder, the next point to be looked after is the spring tension which pushes the brush against the commutator. This spring tension should be just enough to press the brush evenly but firmly aganst the commutator. The brush tension spring is adjustable by putting the end of it in the different notches provided for it in the brush-holder casting, and any degree of tension can be had by using the different notches. When the brush is new and long, it may be proper to run it in the weakest notch. As the brush wears away and gets shorter, the spring unwinds slightly and gets weaker; therefore, it may be proper to move it in the next notch to increase the strength of the spring, but the judgment and experience of the operator will have to determine the brush tension required. It is sufficient to state here that it is always well to run with as light brush tension as possible to still secure sparkless operation. Dirt, overload and too light brush tension causes sparking. Excessive wear of the commutator and brushes is caused by the brush tension being too heavy. A happy medium is about the proper thing.

4. OILING.—The oil chambers should contain enough oil to give the rings a good dip. The oil level will be seen in the gauge on the sides of the bearings and should be nearly at the top of the gauge. When starting the machine, lift oil chamber covers and see that the oil rings are turning freely and carrying oil to the shaft. The old oil should be drawn off by unscrewing the drainage plug at bottom of the bearing every month or two, and replaced with new oil. Use only light machinery or dynamo oil. If the oil is too heavy, the rings will not revolve and the bearings will not be lubricated. If the oil is too light, the bearings will run hot.

5. SETTING OF BRUSHES.—Machines are shipped from the factory with the brushholders and brushes properly set. The position of the brushes is approximately half way between the poles. In the motor, they are placed one or two segments back (that is, against the direction of rotation), of the exact middle, or neutral point, while in the generator they are set one or two segments forward. The brushholders should be placed on the studs, so that the brushes will not run in the same line on the commutator. This will help to avoid grooving.

6. STARTING SET.—First see that the starting box lever has moved back to the off position. If there is a regulating rheostat on the motor end, its handle should be moved as far as possible in a contra clockwise direction. If there is one on the generator end, its handle should be moved as far as possible in a contra clockwise direction. Close the main switch and move the lever of the starting box over the contacts, taking about one second for each, until it is against the magnet which will hold it. If the set has not started when the fourth contact point is reached, open the main switch and ascertain the trouble. When the set is running, the current may be adjusted by means of the regulating rheostats.

7. STOPPING SET.—Open the main switch and let the starting box operate itself. The lever will be released when the motor has slowed down, when it will fly back to the "off" position. If the contacts become rough and prevent the lever from moving fully back, they should be cleaned with very fine sandpaper. The lever should never be fastened or allowed to stick at an intermediate point.

8. CARE OF BRUSHES AND COMMUTATOR.—When starting, and once or twice a day, the commutator should be rubbed with a piece of cloth or waste having a few drops of ordinary sperm or machine oil on it. This is sufficient lubrication, and the commutator ought to assume a dark brown polish and run for an indefinite period with very little attention. Sandpaper should be used sparingly and only if the commutator has become rough by reason of sparking caused by dirt. See that the brushes are being held properly against the commutator by their springs, and that there is no friction preventing the brush from sliding firmly and evenly on the commutator. Make sure all brushes are *long enough*, as otherwise a short brush will hang up and make poor contact at the commutator, causing sparking, overheating and consequent injury.

FORT WAYNE DIRECT CURRENT COMPENSARC

The Fort Wayne Direct Current Compensarc consists of two machines mounted together on the same shaft, one machine operating as a motor, driven by current from the supply lines, to drive the other machine as a generator for furnishing current for the lamp. Such combinations of motor and dynamo are sometimes called motor generator sets, and the Fort Wayne direct current compensarc for 500 volt circuits is truly a motor generator set. The sets for 115 and 230 volt circuits, however, are not, rightly speaking, motor generator sets, since the electrical connections between the machines are somewhat different from those

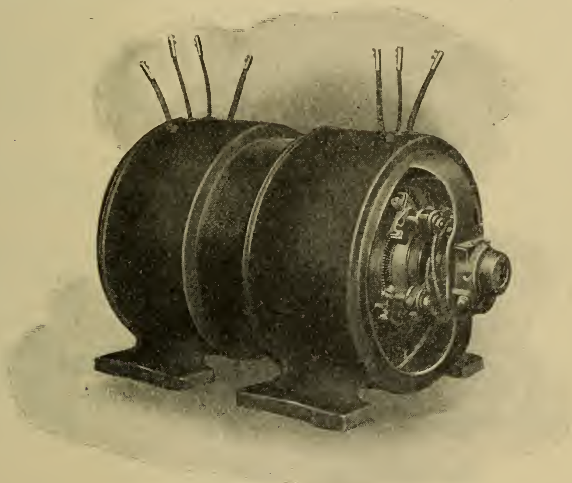


Fig. 92.

of a true motor generator set. The difference will be pointed out under "Electrical Connections." (See Figs 93, 94 and 95.)

The frames of the two machines (Fig. 92) are bolted together so that no special base for mounting is required. Since there are no belts, gears or any connections of that sort needed, the machines can be set in any convenient part of the operating room where they will be out of the way. Rigidly bolted to the frames of the machines are the bearing flanges which carry the bearings for the shaft, and the brushes which fit on the commutators and carry the current to the armatures. The bearings have a special metal lining, which is self-centering.

Bearings are constantly supplied with oil by oil rings which, resting upon the rotating shaft and turning with it, carry oil from the large oil well, located in the bearing flange just under the bearing, up to the top of the shaft. Each bearing has an oil gauge so that the operator can see at a glance the exact amount of oil in the oil well; a little cover over the top of the bearing is provided so that the operator can at any time see if the oil rings are working properly.

The motor and generator armatures are both mounted on the same shaft, and each has its own commutator. The brush yoke, which is mounted on the bearing flange, carries the brushes, which, pressing against the rotating commutator, complete the circuit between the line and the armature.

On the shaft, between the two machines, there is mounted a fan which, rotating with the shaft, sets up a current of air which keeps the machines cool. This fan is surrounded by a perforated metal guard so that there is no possible danger of injury to the operator by accidental contact therewith.

The D. C. compensarc should be installed in a clean, dry, well ventilated location, and, if possible, near the lamp which it is to operate. It is not necessary to furnish a foundation, but the floor should be firm and free from vibration.

Before setting the machine in place, see that it is perfectly clean, and that the brushes move freely in their holders, make good contact with the commutator, and are properly set, according to the markings on the brush yoke. See that the armature turns freely in the bearing; that the machine is level and that the oil wells are properly filled with a good grade of lubricating oil. All external connections should be carefully gone over and checked up with the diagram of connections, Fig. 95.

ELECTRICAL CONNECTIONS

The direct current compensarcs for 115 to 230 volt circuits are connected as shown in Fig. 93, while those for 500 volt circuits are connected as shown in Fig. 94. A more simple diagram of the external connections alone is shown in Fig. 95. The diagram in Fig. 95, which is correct for machines of all voltages, is practically the only one to which the operator will ever have occasion to refer, since all internal connections are carefully made before the machine is tested at the factory, and are as they should be when the operator receives the machine. It is only in exceptional cases that some trouble inside the machine may necessitate the opening of the internal connections. In such cases Figs. 93 and 94 should be referred to in re-connecting.

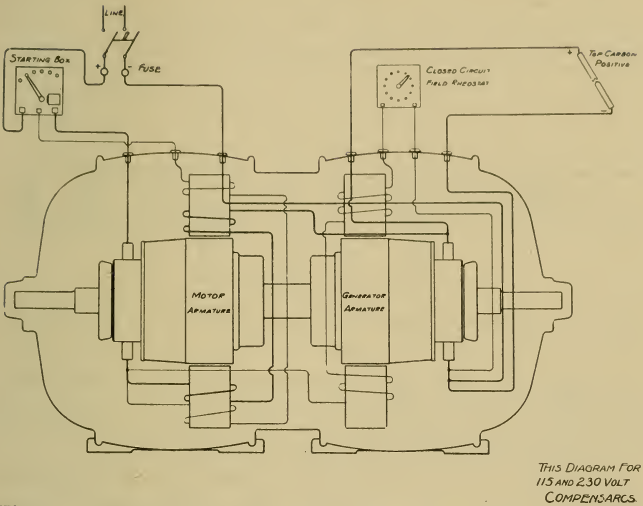


Fig. 93. Internal Connections for 115 and 230 volt compensarcs.

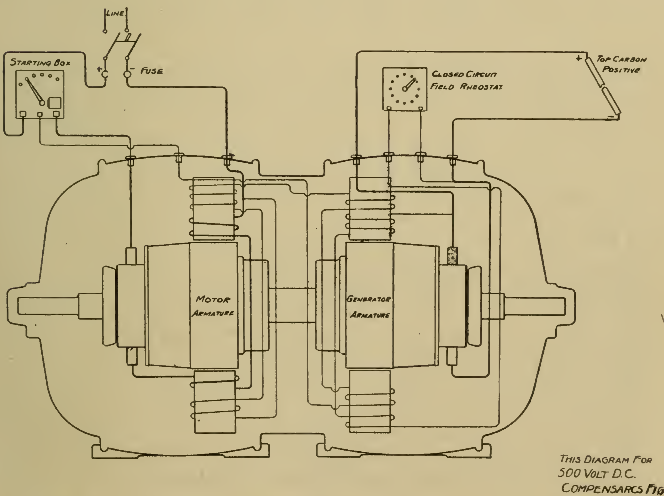


Fig. 94. Internal Connections for 500 volt compensarcs.

The wiring should be of sufficient size so that the line drop from the machine to the lamp will not exceed one volt, or 2 per cent., when carrying the full load current. By using too small a wire the lamp will be robbed of some of its voltage, and thus

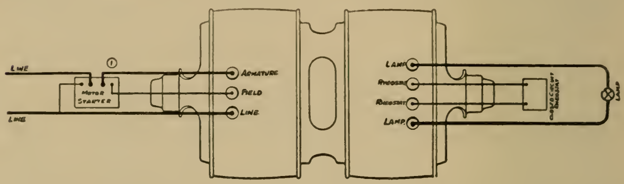


Fig. 95 External Connections for compensarcs of all voltages.

the illumination will be injured through no fault of the compensarc itself. The lamp side of the machine need not be fused, as the machine is so designed that it will protect itself against an overload of current when the carbons are together.

The motor, or line side, of the machine should be fused as follows:

30 ampere fuses for 115 volt circuit.
15 ampere fuses for 230 volt circuit.
10 ampere fuses for 550 volt circuit.

It is essential that the carbons in D. C. arc lamps have the correct polarity, viz: That the upper carbon be positive and the lower carbon be negative. See pages 12, 207 and, especially, 224.

After seeing that the foregoing instructions are carefully carried out and everything is in proper shape, the lamp carbons being separated, close the main switch; the armature will then begin to revolve. Next move the lever of the starting box slowly to the right, as the machine speeds up, until it reaches the last step, when it will be caught and held by a cut-out magnet. After the machine has reached its speed limit, and is operating properly, adjust the voltage at the carbons by moving the lever on the field rheostat, so as to give approximately 90 volts at generator at no-load and approximately 55 volts when carrying rated current. As the machine heats up or more light is needed, for dense films, the rheostat should be adjusted to give the required current and voltage at the arc. When the rheostat is set at the *"running mark,"* you will get approximately 55 volts and 35 amperes with the arc burning, or 85 to 95 volts with the carbons separated or open-circuited.

If you have no ammeter or voltmeter, the operator's experience must be relied upon for adjustment, but both ammeter and voltmeter are strongly recommended for the arc circuit. For most films, about 35 amperes, and 50 to 55 volts, will give a clear picture. In large theaters where the throw may be long and all the lights going in the hall, 35 to 40 amperes may be needed, or with a dense film it may be found necessary to run the current up as high as 45 to 50 amperes. The volts at the arc, of course, must be brought down slightly, that is, while 55 volts is about right for 35 amperes, 45 to 50 volts will be found more satisfactory when the current is increased to 40 or 45 amperes. Below 60 volts the arc emits a hissing sound and gives a very unsteady light; and the hissing disappears immediately upon raising the voltage to 50 or 55 volts, depending somewhat on the kind and condition of the carbons. Above 55 volts the arc will flame, giving less light, which will be unsteady.

To shut down the compensarc, simply open the main switch, when the armature will slow down and stop, and the starting box arm will automatically spring back to the starting position; the field rheostat being left in a running position, the outfit is ready to start without any further adjustment.

To the Operator.—The following points should be kept in mind in operating this equipment:

1st—Keep the upper carbon positive. This will be indicated by its remaining hot the longer after the power is cut off.

2nd—Keep the machine clean. It is good practice to use a small hand bellows, occasionally, to blow out any carbon or copper dust that may have accumulated from the wear of brushes and commutator.

3rd—Keep the contacts and connections tight.

4th—Keep the lamp and machine free from grounds.

5th—Keep the oil wells full (not overflowing) of clean, good grade lubricating oil.

6th—Keep the commutator clean. A cloth moistened with oil should be kept for this purpose. The commutator and brushes should be kept free from gum, which is readily removed by kerosene or a similar oil.

7th—Never use emery of any description on the commutator. If the commutator roughens, fine sandpaper (00) may be used, to smooth it, but sandstone, such as dealers supply for the purpose, is to be preferred.

8th—The setting of the brushes is an important matter. When sent out from the factory the brushes have been carefully spaced equal distances apart around the commutator, and the proper position of the brush yoke, which carries the brush studs, has been carefully marked with a chisel. These chisel marks on the brush yoke and bearing flange *must* match up, otherwise the machine may spark at the brushes or operate in an unsatisfactory manner.

9th—It is also important that the brushes properly fit the commutator. Before a new machine is sent out the brushes are ground to fit the commutator. When new brushes are put on a machine they should be fitted to the commutator by placing around the commutator a strip of rather fine sandpaper, the width of the commutator, and long enough so that it will lap about one-quarter of the way around the commutator. All the brushes should be lowered on to this paper, with brush springs in proper position. The armature should then be revolved by hand in the direction in which the machine operates, until the brushes are ground to a proper fit. A clean piece of very fine sandpaper should lastly be used to remove any scratches from the face of the brush which may have been left by the coarser paper. All the carbon dust should be blown from the machine at the end of this operation.

Possible Troubles and How to Correct Them.—Should you have trouble, a systematic inspection should be made to locate its cause. In nine cases out of ten, the trouble will be a small matter which can easily be remedied if gone about carefully and intelligently. Below are given some of the more common difficulties in such machines, with instructions for finding and correcting them.

1st—Machine Will Not Start. If the machine does not start when the switch is closed, first examine the fuses and make sure that the current is on at the switch terminals. Then trace and inspect the connections from the switch through the starting box, armature, commutator, brushes, field and back to the switch, and you will probably find an open connection somewhere in the circuit.

2nd—Machine Blows Fuses. Look at the fuses carefully to make sure that they are of the proper size for the circuit used and are not loose. Examine the starting box for grounded or short-circuited resistance coils. Look inside the machine and see that connections are not touching inside where they are not easily seen. See that the brush yoke and housing marks agree, so that brushes set in the same place as when adjusted at the factory. Look all around the commutator at the connections between the armature winding and the commutator bars. By the time you have made this minute inspection you will in all probability have located the trouble.

3d—Machine Makes Excessive Noise. This you will most often find due to a weak floor, or to the machine not setting firm and level. If the noise seems to be in the machine itself, better shut down and send for an electrician. You might burn out your armature if the trouble is not corrected. If the machine is kept clean—dirt all blown out of the inside once a week—this trouble will not be very likely to occur.

4th—Bearings Run Hot. The first rule when a bearing runs hot is to see that the oil well is filled with good, clean oil and *that the oil rings run freely*. If a bearing runs hot on a new machine shut down and wash out the bearing with kerosene. Trouble is probably due to dirt which has accumulated in shipment. If the bearings have been running along satisfactorily and suddenly get hot—flood the well with clean oil, leaving the drain cock open, and pouring in the clean oil while running to free the bearings from dirt. A change to a better grade of oil will often correct a bearing trouble of this kind. Never use water to cool a bearing; it may get into the insulation and start a worse trouble. A machine with clean oil, of good lubricating quality, never gives trouble from hot bearings.

5th—Sparking at Brushes. First see that the brushes are properly fitted to commutator. If they are not, fit them in the way previously described. If the brush fits perfectly it is probable that the sparking is caused by a bit of dirt or copper catching under the brush. Lift the brush and clean it, when the trouble will usually disappear. It sometimes happens that there may be a hard spot in the brush which will persist in picking up copper. Grinding the brush a bit should correct this trouble. When the machine is operating properly the brush should have a smooth unscratched surface free from any deposit of copper, with edges nicely squared off.

Sparking at the brushes is sometimes caused by an uneven commutator surface which may possibly have worn so that a mica may be projecting above the surface. Smooth up the commutator surface with a bit of sandpaper or sandstone, and the sparking will disappear. If the commutator has become so badly worn that it is no longer round, the armature should be removed and the commutator turned down by a machinist. Do not attempt to correct sparking at the brushes by use of commutator compound, or by flooding the commutator with oil. These are not needed and will only make matters worse.

Worn bearings become noticeable in an old machine by the rattle of shaft in the bearings as the machine operates. If the bearings become so badly worn that the shaft can be lifted up and down in them by means of a small screw-driver used as a pry, new bearings should be inserted, for if the machine be allowed to run thus, electrical troubles will be experienced; especially at the commutator.

To Take Out the Armature. 1st.—Remove the perforated metal band between the machines and remove fan from the shaft.

2d—Take off bearing flange at one end of machine.

3d—Remove armature endwise, being careful to prevent injuring armature or commutator by bumping them against the pole pieces.

To Order New Parts.—If it should become necessary at any time to order new brushes or bearings, or any part of the machine which may have become damaged, bear in mind that the serial numbers and nameplate reading of the machine should be placed on all orders, and the size of the carbon brushes should be specified when ordering the same.

The Projector

THE LAMPHOUSE

THE importance of paying attention to the lamphouse and constructing it carefully, along intelligent lines, is being more and more recognized by machine manufacturers. A small lamphouse is an advantage on the road, since it occupies less space in packing and is easier to handle in setting up. Small lamphouses have great disadvantages, however, particularly where laws or department rules require that they be tightly closed when the arc is burning. There is no advantage in a small lamphouse, where it is permanently located in an operating room. It gets very much hotter than does its larger brother, and this has a decided effect in breaking condensing lenses.

A most important point, to which altogether too little attention has been paid by machine manufacturers, is ample ventilation. To date I know of but one American made lamphouse which, in my judgment, has plenty of ventilation. Of course, in many cities it is not allowed, but where it is permitted I certainly advise the operator to remove the whole back of the lamphouse. There is absolutely no danger whatever in so doing, and it keeps down the interior heat and usually eliminates, at least in large degree, condenser breakage.

Where this is objected to it is of the utmost importance that the ventilation holes be kept open and free. The vent opening in the hood is covered with perforated metal, and this screen, designed to prevent the escape of sparks, rapidly clogs up with white ash, the residue of water glass in the carbon cores.

By All Means Clean the Vent Screen of Your Lamphouse Thoroughly Every Day.—Keep the lamphouse clean. Once a week slip it off its rods, take it out of doors and shake it out clean. It may be cleaned without this, of course, but this is the best way. If the lower carbon-jaw of your lamp, or the carbon itself comes or can come into contact with the metal of the front wall, line the wall with sheet asbestos. It is also a good scheme to rivet sheets of asbestos to the door or wall of the lamphouse opposite the lamp binding posts. Many annoying grounds are caused by a stray strand of the asbestos covered lampleads protruding and making contact with the lamphouse.

Arc Projector.—When handling A. C. it is essential that the operator have some means of examining his arc. To secure the best results he must be able to see either the arc itself or a perfect image of it. A combination of one thickness of ruby glass, of not too dark a shade, and one thickness of "pot green," clamped over a hole three inches in diameter, cut in the lamphouse door a little higher than the arc and near the front edge of the door, will enable the operator to examine the arc itself with absolutely no eye-strain. A hole 1/32 of an inch in diameter drilled in the lamphouse wall on the side opposite the door, or in the door, if there be one, on the opposite side from the operator, will, without the use of a lens, project an enlarged image of the arc, though upside down, on a white cardboard placed to receive it, or on the wall of the room. This hole should be located exactly opposite the arc. Inasmuch as the arc must be moved ahead or back to accommodate the different focal lengths of condensers, it is well, if there is any likelihood of changing focal length of condensers, to make a small slide in the door which may be moved ahead or back an inch or so, and drill the hole in this slide. Do not make the hole larger than 1-32-inch, or the image will be blurred. By means of the image one is able to see exactly how the crater is burning and correct any tendency it may have to form wrong, before any bad result shows upon the screen.

Keep the slide rods (if you slide the lamphouse over to a stereo lens) well lubricated.

THE LAMP

This is a subject worthy of considerable space. Light is the foundation of projection and the lamp is an important factor in the production of good light. In fact, the production of the best projection light is impossible with a poor lamp, or with one that is dry, loose and "wobbly." Many an operator is producing poor results on the screen for no other reason than that his lamp is: (a) Not well made, or of good design. (b) Not properly lubricated. (c) Has too much lost motion and shakiness. (d) Has charred wire ends. (e) Carbon jaws rough and dirty, thus preventing good contact between the carbon and metal.

It matters not how excellent your lamp may be, in itself; unless you keep it well lubricated you cannot handle it properly, hence cannot make fine adjustments of the arc. The lamp should be taken apart occasionally and thoroughly lubricated with graphite. Grease or oil does little good since it is quickly burned off or dried up by the heat. *A box of good powdered graphite is an absolute necessity in the operating room.* Seventy-five cents will get a can large enough to last a year or more if you do not waste it. *By all means get a can at once if you haven't it already.* Take the lamp all apart, *except the insulated joints, which should not be disturbed.* Take out every screw. Grease all screws and moving parts with oil. Wipe off the surplus oil, and then drop the parts into a box of graphite. The oil is only to make the graphite stick. Take out the parts and shake off the surplus graphite (don't wipe it off, just shake the parts), and put them back. You will be surprised how much easier your lamp will work, and how much better you can gauge your light. Do this once a week if using heavy amperage and running ten hours a day. If running evenings only, do not do it so often.

Every Day, Before Starting the Run, Take Out the Carbon Clamp Screws and Lubricate Them With Graphite.

You will not need to twist them up with a plier then. In fact, the screws will work so very much better that you will most likely crush the first carbon you put in by excessive pressure.

Of late there has been immense improvement in lamps. They are made heavier and more substantial. If you have one of the old, weak, small lamps, you had better throw it away and secure a new, modern one. A lamp with small rack-bars is an abomination. Nine times in ten they do not fit snugly in their bearings and the carbon arm wobbles sidewise from an eighth to a quarter of an inch. Good light with such a lamp is impossible. The lamp should be rigid and have no appreciable lost motion, sidewise, in its carbon arms.

The old nuisance of weak carbon clamps has largely been done away with. Nearly all manufacturers now use clamps of ample strength to withstand the strain. However, if you are troubled with clamps breaking, have a blacksmith make you a pair from steel, using the old one for a pattern. They are just as good, from the electrical point of view (due to the large cross-section), as any, and will last for years.

For the benefit of those desiring to make a pair of clamps of their own an excellent pattern is illustrated in Fig. 96. The detached piece slips into opening 2 to clamp the wire. Such a clamp may be made from brass, bronze or steel, preferably the latter. The cross-section of the short clamp is so great that its electrical resistance amounts to nothing. One very essential thing is to keep the inside of the carbon arms and clamps, where the carbon makes contact, perfectly clean. This is very important, indeed, and altogether too little attention is paid to it. If the inside of the contacts get dirty and covered with scale, very high resistance will result.

Carbon arms and clamps should be thoroughly scraped out at least once a week; oftener if high amperage is used.

Lamp heads should be attached by means of a copper terminal, one form of which is illustrated in H, Fig. 5. The wires inside the lamphouse oxidize very rapidly, especially when heavy amperage is used. As soon as they feel soft, having no life or spring to them, cut them off, strip the insulation back as far as the wire is discolored and cut the wire off there, throwing the burned ends away. When using 45 amperes D. C. or 60 am-

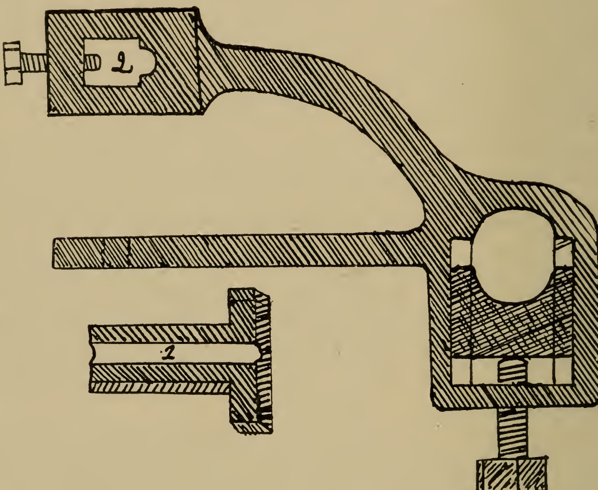


Fig. 96.

peres A. C. this should be done after about 48 hours' actual use. The burned wire ends develop high resistance; they thus waste power and injure the light. It costs about 20 cents to cut a foot off each one, but *it pays well to do it.* Many operators, not realizing this, run their wires until they are ready to burn off, or actually do burn off. They have wasted several times the cost of the wire in wasted power, which registers on the meter, and they have injured their projection light as well. Every time you disconnect the wires from the lamp, scrape the contact until it shines. It is difficult to maintain good electrical contact, at these connections, owing to the heat of the arc oxidizing the metal. A thin, almost invisible, scale forms, which has very high resistance; hence frequent cleaning is necessary.

The insulation between the carbon arms and lamp must, of course, be perfect. It often happens that carbon dust will settle on top of the lower carbon arm until a bridge is formed across the insulation, thus causing a ground.

The insulation between the lower carbon arm and the lamp should project up at least one-eighth inch above the metal.

If the lamp has not insulation projecting thus when you receive it, loosen the joint and insert a piece of mica, allowing it to stick up above the metal about one-eighth inch.

A good lamp should have the following adjustments, all capable of being made by means of adjustment wheels *outside the lamphouse.* (a) Up and down. (b) Backward and forward. (c) Sidewise (which may be accomplished equally well by moving the whole lamp sidewise or by swinging it). (d) Movement of rack-bars to feed the arc. (e) Side movement of upper carbon, independent of the lower one. (f) Backward and forward movement of the top carbon, independent of the lower one. These last two movements are of the utmost importance, since it is only by them that the crater can be properly handled and compelled to form in proper position. (See "Setting the Carbons.") The backward and forward movement of the whole lamp should be accomplished by means of a very coarse screw, or its equivalent, since there is no use in being obliged to give the adjustment wheel half a dozen turns in order to move the lamp a quarter of an inch.

It was at first intended to illustrate in this book all the different lamps put out with the various machines, but this would consume much space without commensurate benefit. The types of projection lamps are changing very rapidly just now, and the matter would very soon be out of date anyhow. It is therefore omitted.

The Angle at Which the Lamp Should Be Set is a subject of considerable argument and discussion, particularly where alternating current is used. For direct current practically all are agreed that the angle should be as much as possible without causing the lower carbon tip to interfere in the light (See "Carbon Setting.") With A. C., however, there is diversity of opinion. Some even claim that better results are obtained by setting the lamp so that the carbons are straight up and down. With this I have always and do still disagree. I am of the opinion that the lamp should be set at practically the same angle for both A. C. and D. C.

CARBONS

The carbon is a subject of much importance, since the carbon is really, in a way, the source of light. However, it is scarcely necessary to consume space in setting forth details of their manufacture, except very briefly.

Carbons are composed of carbon of various grades, usually gas retort, soot, coke, or soot obtained from certain woods, which is held together by a suitable binder. The carbon is first powdered by many steel rollers, then subjected to magnetic action for removal of iron particles, also to other purifying processes. It is then mixed with a liquid binder, kneaded into a stiff mass by machinery and placed in a steel press, in the bottom of which is a hole of the size of the outside diameter of the carbon to be produced. If cored, a steel needle is fixed in center of the hole. The carbon dough is then forced through the hole under very great pressure. It comes out in the form of a continuous round rod, which is cut into proper lengths and straightened. The carbon rods are next packed in pulverized carbon and baked for many hours at a temperature of about 2,700 degrees Fahrenheit. They are then tested for straightness and, if to be cored, the core is forced in. They are then cut into commercial lengths, pointed and packed for shipment.

The binder most commonly employed is coal tar, which is also reduced to carbon in the baking. It is highly essential that the binder be efficient, since otherwise when using amperage near the capacity of the carbon, the binder will burn out more rapidly than the carbon itself is consumed, thus allowing the carbon to disintegrate. It is largely this that causes what is known as "needling," i. e., carbons burning to a long, slim point.

The core is formed of powder resulting from grinding up defective carbons, which have already been baked. It is forced into the central hole after the carbon has been baked. It is held together by a substance known as "water-glass," the same being a soluble, alkaline silicate. From it comes the white ash which coats the interior lamphouse walls when cored carbons are used.

The purpose of the core is to offer a path of somewhat lower resistance than the body of the carbon itself. This tends to hold the current central in the carbon, which in turn has the effect of holding the light steady. If a solid upper carbon be used the light will jump from side to side, or up and down, causing constantly recurring shadows on the screen.

Cracks running lengthwise of a carbon do no harm whatever. They are an evidence that the carbon has been well baked. Cracks running around the circumference of a carbon condemn it. Reject any such carbons. With cored carbon the core must be continuous throughout, else it will be impossible to maintain steady light. There are few things more aggravating to an operator than a carbon with a poor core. Therefore, reject any carbon in which the core appears to be defective.

Carbons which do not run uniform in density throughout their length—those that have "hard spots"—are another source of trouble. They are absolutely unfit for projection work. A hard spot will cause the arc to flutter and jump, and it burns away very slowly. Carbons that are too soft will needle badly and burn away rapidly, while if too hard the light will flutter and be yellow. It is absolutely essential that the operator be able to depend absolutely on the uniform, constant excellence of his carbons. He should, therefore, be very careful indeed about changing his brand of carbons, if he is getting good results.

The latest lamps are made to take a carbon six inches in length below and a ten or twelve inch one above. This eliminates much waste, since there will be just so much stub end to each carbon, whether the carbon be six or ten inches long. However, there are those who claim the additional resistance of the long carbon is very detrimental. This I do not think holds good, unless the carbon is working beyond its capacity. I do not mean that the carbon resistance is negligible. It is really considerable, and some authorities believe it to be sufficient to cause rejection of the long carbon.

The constant annoyance of resetting carbons every reel, together with the large waste of carbon in butts, however, I believe more than overbalances the extra resistance loss of the long carbon. Actual experiment by the writer has proven that, with 50 amperes flowing through a closed circuit, the insertion of ten inches of ⅝-inch carbon only reduced the current flow by about one ampere.

Size of Carbons is a matter to which the average operator gives too little attention. Nine out of every ten use either two ⅝ inch cored, or a ⅝ cored above and a half inch solid below, regardless of amperage. This is not good practice. For direct current I recommend ⅝-inch cored above and a half inch solid below, where the amperage is between 25 and 45. If less than 25 use a half inch cored above and 5-16 inch solid below, or, if unable to get 5-16 then use half inch solid below. They will burn away faster, but will give better results. In this connection let it be remarked that if you have a rheostat rated at 25 amperes you are most likely really pulling only 20, or may be 18, after it has been used a short time. If your D. C. amperage is above 45, use

¾-inch cored above and ⅝-inch solid below. For A. C. use ⅝-inch cored above and below for amperage up to 60. From 60 to 80, use ¾-inch. I have not experimented, but I think likely that a half inch cored carbon might give better results where the A. C. amperage is, if it ever is, below 40. However, you will never get good results with less than 35 amperes A. C., no matter what you use, unless the picture be very small indeed. I have been told, but have not tried it out, that ⅝-inch cored carbon above and a half inch cored below give excellent results with A. C., though the half inch carbon burns away very rapidly.

SETTING THE CARBONS

A subject second to none in importance. It is a point over which many operators have stumbled. A very slight difference in the set of the carbons may make a very great difference in the screen illumination.

Practically all illumination available for use comes from what is called the "crater." With direct current there is only one crater, but with alternating current there are two. It is this fact which makes A. C. so very poor for projection, as will be explained in detail presently. The crater is a depression which forms in the center of the point of the positive carbon with ordinary arc lamps in which the carbons are set perpendicular and central with each other. In the case of the projection arc lamp, however, the crater must be and is formed on the lens side of the positive carbon tip. There is no known method of measuring the temperature of an arc light crater, but it has been variously estimated as high as 8,000 degrees C.

It will be noticed by operators that with 110 volt current the carbon tips, when cold, may be brought very close together without effect of any sort. They must be brought into actual contact before there is result. It will also be noted that, although the carbon tips may be separated from ⅛ to ⅜ of an inch with the arc burning normally, if the switch be opened and immediately closed the arc will usually leap the gap between the still incandescent points and burn again as usual. The phenomenon is due to the fact that the carbon is votalized (transformed into a gaseous vapor) by the arc, and this vapor is in itself an excellent conductor of electricity, while air is a very poor conductor. When the carbons are cold, or only red, they are not being votalized, therefore the vapor is not present. Between the tips is only air, which offers too much resistance for the current to use as a path to the other carbon. For one or two seconds after the arc is shut off, however, the vapor is still given off, hence the space between the carbon tips is still bridged by a tolerably efficient conducting medium of gas.

The crater spoken of is formed by reason of the fact that minute particles of carbon are torn away from the positive carbon by the current. These particles are mostly volatilized as soon as torn off, though some of them reach and are deposited on the negative carbon tip, only to be volatilized there later.

As stated, practically all light available for projection comes from the crater, or craters. It, therefore, follows that, within certain limits, the larger the crater the more light there will be. However, there is a limit to light gain through increased size of craters if the light must be passed through lenses. The theoretical light to work in perfect accord with the optical principles involved in a lens, is a pin-point—that is to say, a light the size of a pin-point. As the size of the illuminant increases the effectiveness of the lens in utilizing it is decreased rapidly until a point is reached where any further gain is at tremendous expense. In practical projection this point is reached when the crater becomes about ½-inch in diameter. Any further increase in size of crater is of comparatively slight value. Moreover, an excessively large crater has a tendency to set up trouble in the optical system, manifesting itself in lack of definition on the screen.

A projection arc must be operated with the carbon tips a certain distance apart in order to obtain the best results, and this distance varies according to number of amperes used, kind of carbons, etcetera. It, therefore, follows that, inasmuch as the carbon tips of a projection lamp cannot be kept the same distance apart constantly and under all conditions, the arc voltage must and will vary. Arc voltage is the pressure necessary to force the current across the arc space. This equals the reading of a voltmeter when same is attached to upper and lower carbon-arms.

It is, however, the number of amperes flowing, and not the voltage, which determines the crater size, hence the amount of light the arc will produce; there being but slight increase in temperature of the crater as the amperage is increased.

But in considering light for projection, this latter must be coupled with another item, viz: Position of the crater. If the crater points downward the greater percentage of light will be thrown in that direction. The condensing lens is located exactly level with the arc. The arc must be, for best results, exactly in line with the optical axis—center—of the condensing lens. It then follows that the more squarely the crater can be made to face the lens, without causing the lower carbon tip to interfere in the ray too much, the greater percentage of light will be available. In Fig. 97 we see this illustrated.

It takes but a glance to convince one that set A is highly inefficient. It is caused by setting the carbons as per 1, Fig. 97.

Such an arc will give off exactly as much light as will any other, but it will be thrown off in the wrong direction to be utilized for projection. No direct ray from the incandescent

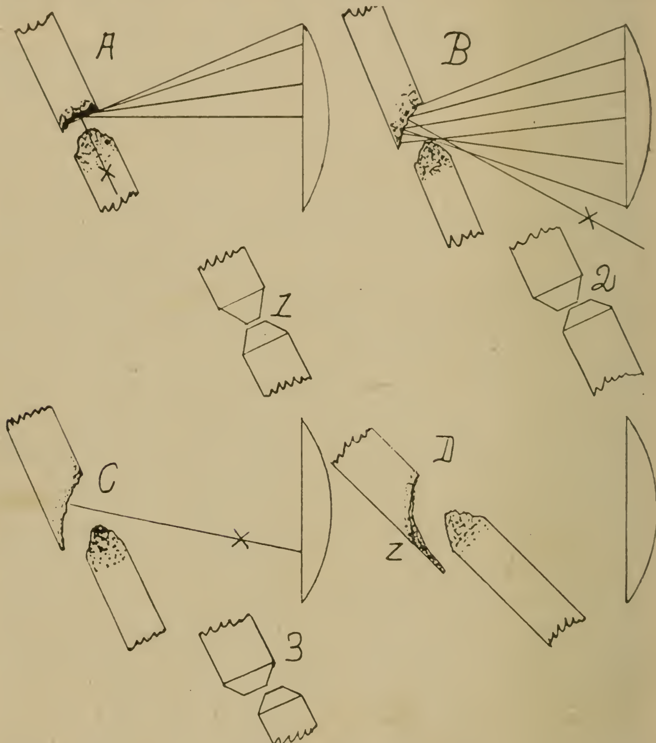


Fig. 97.

crater can reach the top of the lens, and not until the point indicated by the third line down is the entire crater visible to the lens. The strongest light is being thrown directly toward the lower carbon, in the direction of ray X. At B we have a better condition, the entire crater being visible to the whole lens, but the strongest light is traveling in the direction of ray X. This condition is brought about by carbon tips as per 2. At C is shown as good a condition as may be expected to be attained. The most intense light is at point X, quite close to the center of the lens, the whole crater being very nearly square with the lens and the lower tip interfering at a minimum. This is accomplished by tips, set as per 3, Fig. 97.

At A it will be seen that the lower carbon tip begins to interfere at the fourth line down. At B it is somewhat earlier, while at C, in which a longer arc is shown, there is improvement in this respect. At D we see a lamp which is angled too much, causing great interference by the lower carbon tip. These sketches are not designed to accurately portray actual arc conditions exactly as they are, but to set forth, in understandable form, the various faults which must be studied and guarded against as far as possible.

One reason why I have recommended the use of a half-inch carbon below for D. C. is that there is much less interference. The tip of a half-inch solid carbon usually burns to a very much smaller, slimmer point than will the ⅝-inch cored.

The position of the crater, as above indicated, will be governed entirely by the advancement of the lower carbon—that is to say, the distance it is set ahead of the upper one. At 1, 2 and 3, Fig. 97, this advancement is shown, its partial effect being illustrated in A, B and C. At 1, the two tips are set central with each other and the crater will form as at A. At 2, the lower tip is slightly advanced—about half the width of the round points, and we get a crater as at B. At 3, we give still more advancement and have our crater form as at C. However, this advancement may easily be carried too far, the result being that a long skirt will form on the upper carbon at Z, D, Fig. 97; also the crater will form partly behind the lower carbon tip. C, Fig. 97, shows an ideal condition for direct current.

When we consider alternating current, however, we encounter an entirely and radically different proposition; also one in many ways much more difficult to handle. As has been said, the crater always forms on the positive carbon. This is true of both D. C. and A. C.; but it must be remembered that with A. C. both carbons are alternately positive and negative through one-half of each cycle. This means that a crater will form on both carbons.

Now, as has already been set forth, the amount of light will, within certain limits, be directly in proportion to the size of the crater, and how squarely it can be made to face the condenser. The crater producing force being divided between two carbons, it naturally follows that neither will be as large, for a given number of amperes, as would be the case with D. C., with which the whole crater-making force is centered on one carbon. It is even true that both A. C. craters combined will not equal one D. C. crater in size, where equal amperage is used.

Among practical operators, however, it is being accepted as a fact that, due to optical difficulties, it is not feasible to use both craters. That is to say, a better, more uniformly excellent result will be had by only using one—the upper. One effect of using both craters is a double spot at the aperture with liability to produce a dark streak across the screen.

For years an attempt was made to use both craters by means of what is known as the "jack knife" set (B, Fig. 98) ; or by setting the lamp straight up and down, but to-day the best men—men securing best results and holding the best positions—as a rule, use practically the same set for A. C. as D. C., or else use a very modified jack knife set by setting the lower carbon so that it angles out somewhat in relation to the lamp rackbars and angling the top carbon to meet it. But more and more, even this plan is being discarded in favor of the regular D. C. set.

Long ago I advised the same setting for D. C. and A. C., and have had no reasons to change that recommendation. Theoretically the straight up and down set, and the jack knife set, are superior. Practically, as judged by screen illumination, they most emphatically are not. By using the jack knife set one is enabled to get a much higher candle power through the lens for a given amperage. The trouble is, however, the light cannot be maintained steadily, or, rather the curtain illumination cannot be held at uniform brilliancy. Setting the carbons perpendicularly I cannot recommend at all.

These things being true, and assuming we purpose using only the upper crater, it follows that, the light being dependent on crater size, and crater dimensions being dependent on amperage, a sufficient number of amperes must be used to enlarge the crater until desired curtain results are attained. I have already pointed out that the force of direct current is all directed to the formation of one crater, whereas alternating current divides its force between two craters. It, therefore, follows that in order to approximate D. C. results with A. C. we shall be compelled to use a much higher amperage.

The statement is often made that it is impossible to get as good results with A. C. as with D. C. This is not necessarily true, so far as curtain brilliancy is concerned, but it will require double, or more, the number of amperes to do it. With 80 amperes A. C. the same results as to brilliancy to all intents and purposes may be had as with 40 amperes D. C. But that would be very expensive indeed, and fairly good illumination may be had by using the amperage indicated in the table on page 335. There is, aside from brilliancy, a certain harsh quality to A. C. illumination not present with D. C.

Setting the carbons and handling A. C. is something requiring great care and unremitting attention on the part of the operator. Whereas there may be some leeway in carbon setting and length of arc without seriously damaging results on the screen with D. C., the least little thing out of the way with the A. C. set, unless very high amperage be used, seriously affects results. This is by reason of the fact that with the amperage ordinarily used (45 to 60) the crater is relatively quite small. In Australia as high as 100 amperes A. C. is used for projection. In Germany, England, and France, 75 to 90 amperes is not at all unusual. In this country, however, 60 is about the limit, and none of the operating room transformers, so far as I am aware, exceed 60 amperes capacity.

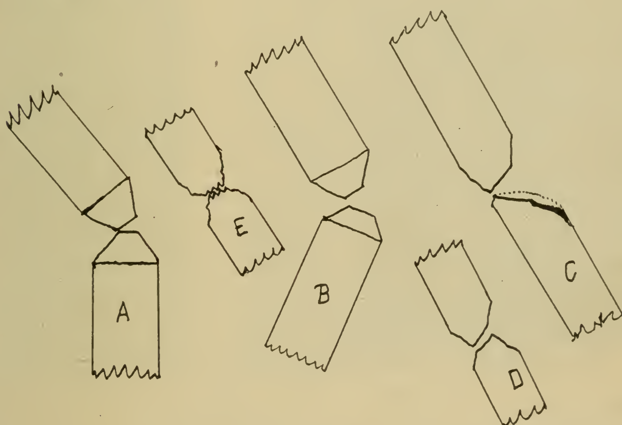


Fig. 98.

With 45 amperes the crater will not be much in excess of ⅛-inch in diameter. With 60 it may reach a diameter of ¼-inch. With 75 amperes, using ¾-inch carbons, a crater very similar to the 30 or 35 ampere D. C. crater is obtained.

With A. C. it is necessary to carry a very short arc — much shorter than with D. C. This reduces the arc voltage from the D. C. average of 48 to an average of about 35. It also renders necessary, as has been said, very close adjustment of carbons.

In Fig. 98, we see, at B, what is known as the "jack knife set," which was much used at one time, but has practically been discarded. It gives a high candle power at times, but is impossible of control in such a manner that the light will be uniform. Theoretically, the craters will form on the two carbon points; practically they form, in more or less ragged shape, at the point of closest contact, and this is not on the point. At A, Fig. 98, we view a modified form of the jack knife set, still used by some operators, though even this is no longer favored by many. This set is also shown photographically at Fig. 99. The trouble with it is that the crater cannot be steadily maintained in one place.

Fig. 99.

D, Fig. 98, shows a condition arising when the lower carbon tip is advanced a little too much in relation to the upper. At C is shown an ideal A. C. crater, and the set the writer firmly believes to be the best for A. C., all things considered. E illustrates the condition arising when the carbons are carried too close together — too short an arc. The light will be very bad. The only remedy is to carry a long arc until the saw teeth are burned off and the crater re-forms.

When using D. C. it may be found that at times a cap with a slim stem will form on the lower carbon, the whole being shaped somewhat like a mushroom. This cap of graphite is caused by carrying too short an arc—that is, keeping the carbons too close together. When the carbons are kept too close together, with D. C., there is not sufficient air admitted to the crater to complete the volatilization of the carbon. Under these circumstances, the carbon particles carried from the crater are transformed into graphite, and deposited on the lower carbon tip. Graphite has high resistance and is consumed very slowly. The remedy is to knock the tip off with an insulated screw-driver and be careful not to again carry too short an arc.

Another very important item is to be very sure that your carbons are exactly in line with each other up and down laterally, or sidewise. This is illustrated in Fig. 100. The carbons must be so set that the dotted line is central throughout their entire length. Often I find the lamps with the lower carbon tilted out of plumb and the top one straight up and down, or vice versa; or maybe neither one is straight. I am referring to the carbons being in line up and down as one looks in through the condenser opening. Unless the carbons are in line with each other, as per Fig. 100, they must be re-adjusted sidewise while they burn

Fig. 100.

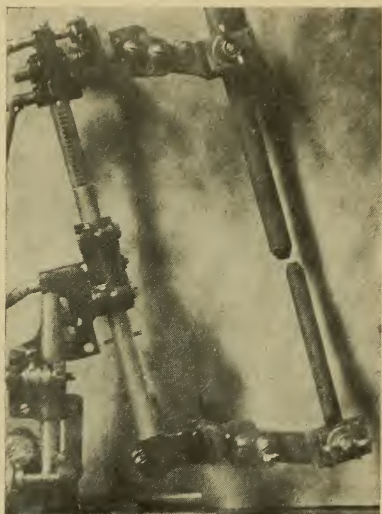


Fig. 101.

away, since otherwise the crater will burn to one side as the carbons are consumed. The remedy is to take the lamp out, place it in a vise, twist jaw or jaws, until the carbons line exactly with the rack bars, which latter you can tell by sighting. You can also accomplish the same thing by filing the jaws carefully, and with some lamps, it is possible to accomplish the purpose by loosening the screws holding the carbon arms and shifting them.

In closing this subject let me again caution you, at the risk of criticism for repetition, to be very careful in setting your carbons, especially with A. C. If you have a modern lamp with the adjustments before named (page 201), you can readily remedy a fault in the set after starting the arc, but with the old style lamp this is impossible.

In Fig. 101 we see the regular carbon set, the one I strongly advise both for D. C. and A. C., photographically illustrated. There is a 5/8 cored carbon above and a 1/2-inch solid carbon below, which is only correct for D. C., from 25 to 45 amperes. For A. C. both carbons should be of equal size and cored.

Soaking Carbons in Salt Brine. One of the main objections to A. C. for projection purposes is the fact that the illumination supplied by it has not the soft, white, mellow tone of the D. C. projection light. Many experiments have been made, with a view to improving A. C. projection light in this respect, and there has been discovered a treatment for cored carbons that seems to really have considerable effect. It has already been published in the Projection Department of the Moving Picture World and many operators have made practical tests of the scheme and the reports have almost invariably been favorable. It consists of the following: Prepare a solution of salt and water, sufficiently strong so that a fresh egg will float with about two-thirds of its diameter out of the brine. Soak the carbons in this solution for fifteen days, then dry them thoroughly, either by allowing them to lie in the sun for several days or by laying on top of a heated stove. It seems to be best that the carbons should be pretty warm when placed in the holder. Carbons treated thus do not seem to strike the arc readily unless they are warm, therefore keep a few of them lying on top of the lamphouse or condenser casing ready for use.

Some treat only the lower carbon, leaving the upper one without soaking. Others treat both. I am not prepared to say which is the better. Salt-treated carbons flame a little more than untreated stock, but they seem to give a softer, whiter illumination, with considerably less consumption of current. I recommend that operators who are using A. C. should give this matter a thorough trial.

The Mechanism.

THE operating room, switchboards, motor drives, transformers, rheostats, switches, lamp, lamphouse, etc., have been dealt with elsewhere. We shall, therefore, now proceed to the consideration of the various moving picture mechanisms. There are certain general instructions applying alike to all machines, as follows:

General Instruction No. 1. Oil.—There are almost as many different ideas concerning the best lubricants for moving picture mechanism as there are operators. There are in general two courses open for lubrication, viz: A light oil, with frequent lubrication, or a heavier oil used less frequently. Words may be said in favor of either. The more frequent application of the light oil will keep the bearings washed out better, but it has a greater tendency to run off and smear around, getting all over the film and machine. The heavier oil will naturally "stay put" better, but it does not keep the bearings so clean. *Never use more than one drop of oil on any bearing.* Anything more is worse than useless, since one drop is ample for all purposes of lubrication, and anything in excess of that will run off, making a dirty mess, and probably get on the film.

I cannot fulfill my duty without warning you against the use of very thin, much advertised patent oils. They are not fit for use on a projection mechanism, and are annually costing exhibitors many thousands of dollars in repair bills. The very thin oil—oil which flows like water—is not fit for use on a moving picture mechanism.

A good grade of light dynamo oil is best for the bearings. For the gears there are several very good lubricants, among them: automobile cylinder oil, bicycle chain lubricant, and a good grade of vaseline. Automobile axle grease is also used successfully. I am also informed, though I have not had the opportunity of testing it out, that beeswax is an ideal gear lubricant. I cannot recommend this lubricant because I have not at this time had proof of the foregoing. It is certainly, however, well worth trying out. A light oil is not suitable for gears. If grease or oil is used the gears should occasionally be washed out thoroughly, say twice per week. This may readily be done without removing head from table by holding a shallow dish (a pan about 2 x 8 inches by 1 or 2 inches deep is best), under the gears while you turn the crank slowly at the same time flooding the gears with kerosene, benzine or gasoline from an ordinary oil can, such as is used to oil the machine. If preferred the mechanism may be removed from the table and, after removing lenses, immersed in gasoline, the crank being given a few turns while the mechanism is in the bath. This washes out both gears and bearings. Washing out gears is of much importance since dust mixes with the oil and forms a grinding paste which wears the metal rapidly.

If the intermittent movement of your machine is in an oil well, a good grade of lubricant should be used therein. Some manufacturers recommend high-grade vaseline for the oil well, the same being melted and poured in. Other manufacturers recommend automobile cylinder oil, though the latter has a tendency to make the machine run a little hard, I think, until it gets warmed up. However, whatever you may use in the oil well, let it be high-grade of its kind.

General Instruction No. 2.—The take-up tension should be kept set just barely tight enough so that it will take up the entire reel of film. Anything more than this is not only bad; it is *very* bad. It must be remembered that when the take-up first begins to act, the amount of film on the reel in the lower magazine is small, and, the tension being the same all the time, the pull on the film, as it comes down from the lower sprocket, is a great many times more than after the film roll on the lower reel becomes large. For this reason, unless the take-up tension is kept as slack as possible, there will be a constant liability to lose the lower loop in the earlier part of the run. Also there is likelihood of pulling weak patches in two, and in every way the heavy strain is detrimental. There is a large need for a practical, feasible arrangement which will automatically supply an even tension to the take-up throughout the run, but such a device has not yet been invented.

General Instruction No. 3.—The sprockets of your machine should be kept perfectly clean, particularly the intermittent sprocket, and the best way to clean them, is to use an ordinary tooth brush, which may be moistened, if necessary, with a little gasoline, benzine, or even kerosene. The faces of the sprockets should be thoroughly brushed at least once every day. It must be clearly understood and remembered that dirt on the face of the intermittent sprocket will cause the picture to jump on the screen, and that dirt on the face of the upper, or lower sprocket, will have a decided tendency to cause the film to leave the sprocket. It is an astonishing thing that many operators do not grasp so obvious a thing as this. I have actually seen machines sent in from a distance of more than 2,000 miles for repairs, the sole complaint being that "the picture jumps on the screen," when the only thing in the world that was the matter, was dirt and gum collected on the face, or rim of the intermittent sprocket. Having this gum and dirt cleaned off, the picture ran perfectly, without a movement. Imagine sending a machine more than 2,000 miles to have the face of the intermittent sprocket cleaned off; a thing the operator could have done in two minutes, and at the expense of a ten-cent tooth brush.

General Instruction No. 4.—The sprockets of your machine must be kept in perfect line with each other, and with the aperture. This is accomplished in various ways with the various machines, but whatever the method, it must be accurately done. The meaning of this is set forth in Fig. 101A.

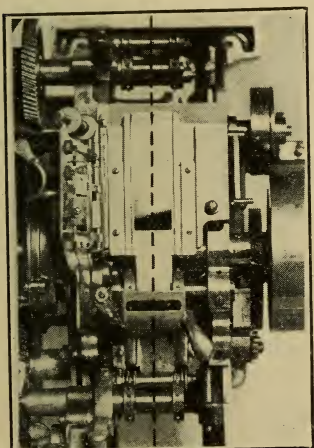


Fig. 101A.

In Fig. 101A we see three sprockets and the aperture, with a central line drawn through them. The teeth of each sprocket must be equi-distant from this central line, and the central line must pass exactly through the center of the aperture. The alignment of intermittent sprocket, upper sprocket and aperture may be tested by placing a short strip of film (don't use worn film for this purpose) in the machine with the gate open. Place it on the intermittent sprocket and close idler. Engage sprocket holes of film with teeth of upper sprocket and turn flywheel backward until film is stretched tightly, being careful that teeth are in center, sidewise, of sprocket holes. If sprockets and aperture are not in perfect alignment the fact is readily detected by the film edge not being in line with tracks on aperture plate or the aperture not being central in film. If film seems to bear equally on both edges of both sprockets and the aperture plate tracks are not straight with film, it would indicate aperture plate out of true. Gently drive its top one way or the other, as is required, to square it with the film. The first thing to do, however, before making this test is to be certain your intermittent sprocket shaft is in exact alignment with camshaft.

General Instruction No. 5.—The intermittent movement, that is to say, the star and cam, or, in the case of Power's 6, the cam and geneva, must be kept set up closely enough that there is very little circumferential play in the intermittent sprocket. It is unwise, however, to set the star and cam close enough so that there is no play in the intermittent sprocket when the machine is cold, since if you do this, the expansion of the parts through heat, transmitted from the spot and created by mechanical friction of the parts, may cause binding and unnecessary and excessive wear of the intermittent movement.

General Instruction No. 6.—The top idler, on the gate, or whatever takes its place, is for the purpose of holding the film central over the aperture and preventing side motion. It should be kept so set that it holds the film snugly, but without binding, and so set that the film will be exactly central over the aperture. If this guide is set loosely enough to allow the film to have side play, then there is likely to be side motion of the picture on the screen. If it be set too far to one side it may cause the sprocket holes to show on the screen.

General Instruction No. 7.—There should be no end play at all in the intermittent sprocket. If there is end play, then there is likely to be side motion of the picture on the screen. It does not necessarily follow that the picture will have side motion because there is end play in the intermittent sprocket, but it is likely there will be.

General Instruction No. 8.—Never use an intermittent sprocket after its teeth become appreciably worn. The using of an intermittent sprocket with worn teeth is bad, from any and every point of view. It is hard on the film, and is likely to cause the picture to jump, or at least be unsteady; also it has a tendency to cause the film to climb the sprocket teeth, thus losing the loop. In fact, the effect of worn intermittent sprocket teeth is altogether bad, and it does not pay to use such a sprocket.

General Instruction No. 9.—The tension springs of your machine should be kept set just right. The majority of operators do not understand the importance of this matter, or else do not know what constitutes proper tension. If the tension is too tight, it has a decided tendency to wear the entire machine, particularly the intermittent movement, and the aperture plate tracks. It also is very hard indeed on the sprocket-holes of the film. The tension may be considered as being approximately right when the picture is steady, and without movement on the screen, when run at any speed, up to say 90 per minute, but at 90 or thereabouts, the picture will begin to crawl up slightly on the screen. Another fairly accurate test is to set the tension so that you can just barely feel it when the crank is turned very, very slowly (and by very, very slowly, I mean just what I say)—just barely moving. If you can feel the jerk of the tension appreciably, when moving the crank thus, then the tension is too tight. In fact, it is not always necessary to have the tension tight enough so that you can feel it in the crank. The 90-foot-per-minute test is the best.

General Instruction No. 10.—Emulsion on the tension spring. When running "first run" films, the emulsion of which is soft, there is a decided tendency for the emulsion to deposit on the tension springs, or shoes. It gathers on their polished surface in a hard, unyielding mass, which, aside from making the springs jump, is apt to injure the film. When running first run films the tension springs should be examined after each run, and any deposit on their surface should be carefully cleaned off by using a wet cloth (water softens the emulsion instantly), or the edge of a silver coin, or some other soft metal.

Caution: Never use a knife blade, a screw-driver, or other hard steel instrument to scrape emulsion off the tension springs. By so doing, you will be very likely to scratch the polished surface of the spring, thus making matters worse, instead of better. The deposit of emulsion may be, to some extent, prevented by rubbing a piece of tallow on the tension springs, or shoes before running each reel. There is nothing, however, that will entirely prevent the trouble. Excessive use of cement in making patches will also, sometimes cause a deposit on the tension springs, since cement is comparatively soft.

General Instruction No. 11.—The tracks of the aperture plate of your machine should not be allowed to become much worn. Worn aperture plate tracks produce a buckling of the film, and an out of focus effect, usually in the center of the screen; also it may cause an in and out of focus effect—that is to say, the picture will be in focus, and then suddenly jump out of focus, and in again, etc. However, this latter effect may be present when the aperture plate is not worn. It may also be caused by: (a) The tension springs not being in proper position so as to bear squarely on the tracks of the aperture plate. (b) By reason of the film being old, shrunken and dry. (c) By too much pressure by the tension springs. If they bear too hard against the film it is apt to buckle.

General Instruction No. 12.—The sprocket idlers of any machine (except the Edison, in which there is no provision made for adjusting the idlers, and instead a heavy flange is used on the sprockets to prevent the film from climbing), should be set away from the sprocket by about twice the thickness of a film. If these idlers ride too heavily on the film, it is likely to cause it to climb. If, on the other hand, the idlers be set too far away, the same result is likely to be produced. Twice the thickness of a film is the correct distance for the idlers to be set away from the sprockets.

General Instruction No. 13.—It is of the utmost importance that the intermittent sprocket, star, shaft, cam, or flywheel shaft be kept in exact alignment with each other. It will readily be seen that if one end of the star shaft be higher than the other, then one side of the intermittent sprocket will be higher than the other, and the teeth of the lower side of the sprocket will have to do all the work of pulling down the film which will, of course, be very hard on both the teeth and the sprocket holes on that side. The method of aligning these two shafts will vary with different machines, and must be left largely to the judgment and ingenuity of the operator. In all machines, in which the intermittent sprocket, or cam shaft, has a bearing at either end, the adjustment is made by means of eccentric bushings, and there is always the liability, when making an adjustment, to turn one bushing more than the other, thus getting the shaft and sprocket out of level. In some machines the distance between the two shafts at either end may be tested with a pair of calipers. With other machines, however, this test is of no value, since the diameter of one or the other of the spindles is smaller at one end than at the other. The competent operator, however, will certainly be able to devise some effective method for testing this matter, and he should by all means do so.

General Instruction No. 14.—Lining the magazine. The film should come down out of the top magazine and engage with the top sprocket of the machine without any side pull at all, and without touching either side of the magazine valve. This is of much importance, and operators should be sure that their top magazine is so set that the above condition will be complied with. On the door of the upper magazine of most machines will be found some kind of a spring, designed to press against the reel, and supply just a little tension, so that the reel will not continue to turn several times after the machine has stopped, thus unwinding a lot of film in the magazine, and causing a heavy jerk to the film, when the slack is taken up.

The lower magazine should be so set that the film will come down off the lower, or take-up sprocket and enter the magazine without any side pull at all, and without touching either side of the magazine valve. This also is of much importance and should be carefully looked after by the operator. The lower magazine should set perfectly square with the machine, front and back, and should set perfectly straight up and down. If it does not comply with these conditions, then the operator should do whatever is necessary to make it so.

General Instruction No. 15.—It is an excellent scheme to have a reel, the spring of which is fixed just exactly right, for use in the lower magazine, and this reel should be kept for this purpose. It is aggravating for the operator who has to do rapid work in threading up, to be obliged to work with reels in bad condition. Therefore, it is well for the house to own a few reels, which may be used by the operator in place of those furnished by the exchange, many of which not only fail to be in good condition, but in fact, are in bad condition.

THE SHUTTER

(General Instruction No. 16)

To do intelligent work the operator should thoroughly understand the principle involved in the action of the revolving shutter. In order to understand this we must consider that the film is in reality, as has been before set forth, merely a succession of snap shot photographs, taken at the rate of about 16 per second, and strung out one after the other on a piece of celluloid, from 500 to 1,000 feet, in length, that these photographs are successively displayed in front of the aperture and projected one after the other to the screen. As, surely every operator understands, the intermittent movement is for the purpose of stopping these pictures in front of the aperture, during the period of projection, and then moving the film down ¾ of an inch to display the next succeeding photograph on the screen. Just there is where the revolving shutter comes in. If you have an outside shutter machine, slip the shutter off the spindle, and run a few feet of film in the ordinary way. You will find you will have an image on the screen, but that there will be streaks of light running up and down through the picture. This is what we call a "travel ghost." It is due to the fact that as the picture is jerked downward to make way for the next one, the effect of any white object in the film on the retina of the eye is greater than the effect of the darker portion of the film, and we see a white object moving, though we cannot see the movement of the dark part of the film.

Owing to this fact, it is necessary to shut off the light from the screen, during the time the film is in movement, and that is the office the revolving shutter performs. If you turn on the light without a film in the machine (the effect would be the same with the film in, but you would set the film on fire), and run the machine very slowly, raising the fire shutter with your fingers, you will see that the revolving shutter shuts off all the light from the screen every time one of its blades comes in front of the lens. Hence, each time, according to whether your machine has a two or three-wing shutter (some machines have a shutter with only one blade, but this type of shutter runs twice as fast as the two wing shutter, hence it has the same general effect as the two-wing type), a picture is exposed, the light is shut off from the screen. We, therefore, have in effect a succession of flashes of light, and total darkness. However, when the machine is run at normal speed, we do not catch the effect, except in a diminution of the brilliancy of the light.

No matter how many blades your shutter may have, only one, the wide blade, has anything to do with the actual shutting off of the light, during the time the picture is being exposed. As the intermittent sprocket starts to move, the wide blade of the shutter comes in front of the lens and shuts off the light from the screen while the intermittent sprocket is moving and pulling down the next picture for exposure. As the intermittent sprocket stops and the picture is ready for exposure on the screen, the wide blade of the shutter passes from in front of the lens and allows the picture to be projected.

Hence, it follows that the shutter must be so set that it will cover the aperture, or lens, when the intermittent sprocket starts to move, and uncover the lens just as the intermittent movement stops. There, is however, a slight leeway here, and, as a matter of fact, with most machines, the lens is not entirely closed when the intermittent sprocket begins to move. Also the lens may be open slightly when the movement ceases, but if the leeway be too much then travel ghost will be developed.

If the streaks or travel ghost be upward, then the shutter is too late; that is to say, it does not close the lens quickly enough. If the streaks be downward then, on the other hand, the shutter acts too soon and opens the lens too quickly at the end of the movement. All this has to do with the wide blade of the shutter. There are, however, three wings to some shutters and two wings to others. These extra wings have nothing whatever to do with travel ghost, or the projection. As a matter of fact, so far as the projection is concerned, they merely serve to cut off light. They are, however, very necessary. As has been pointed out, the screen is alternately light, and totally dark. Now, if these flashes of light and darkness come too far apart, or are not of nearly equal duration, then the eye sees the darkness in the form of what we term a "flicker," which is not only disagreeable to the audience, but injurious to the eye as well.

If, however, the alternations of light and darkness be brought closely enough together, and be made of approximately equal duration, then the eye will not catch any effect whatever of the alternations of light and darkness, except that there be a diminution of the curtain brilliancy. Therefore, although all these extra blades waste light, they nevertheless serve a very excellent purpose.

The width of the wide blade of the shutter is determined by the rapidity of the intermittent movement. The shutter must revolve one time to each exposure of a picture, or to each movement of the intermittent sprocket. If the picture is at rest during six periods, and in movement during one period, then we could have a much narrower shutter blade than would be necessary if the picture were at rest four periods, and in movement three periods. Hence, the more rapid the movement of the intermittent, the less percentage of the light it will be necessary to cut with the shutter blade. It, therefore, follows that the intermittent movement should be made as rapid as possible, as the slow intermittent movement means a great waste of light. However, the rapidity of the intermittent movement is limited, since if it be made too fast, the strain becomes too great on the sprocket holes of the film.

Fig. 101B will convey an accurate idea of the effective difference in shutters of small diameter and others of larger diameter. In the sketch "X," the aperture opening is 11-16 by 15-16 of an inch. With the small, inside shutter illustrated by the smaller circle c d a, the lines a b indicate the width of shutter blade necessary to cover opening X, without providing for its being covered during the time the film is in motion. Lines a c indicate the additional width of shutter blade necessary to provide for covering opening X during the travel of the film.

You will thus see that with a shutter of small diameter a blade of great width, as compared to the total circle, is essential if opening X is to be covered during the entire time the film is in motion. This is primarily because of the excessive width of blade required to cover the aperture in the first place.

It is not difficult to see that, under these conditions, it would be impossible to add more than one other blade to such a shutter, and even that blade could not be of very substantial width unless a very large percentage of the total light be cut. In practice, however, the inside shutter is not, of course, of such extremely small diameter as shown, but it is nevertheless too small to admit of using three blades of anything like equal width, as is necessary if three are to be used and the flicker reduced to a minimum.

On the other hand, take a shutter of the outside type, having a radius as indicated by 1-2 and 1-3 (radius means one-half the diameter of a circle), and it will be observed that lines A B form a blade covering aperture X, whereas lines B C form a blade

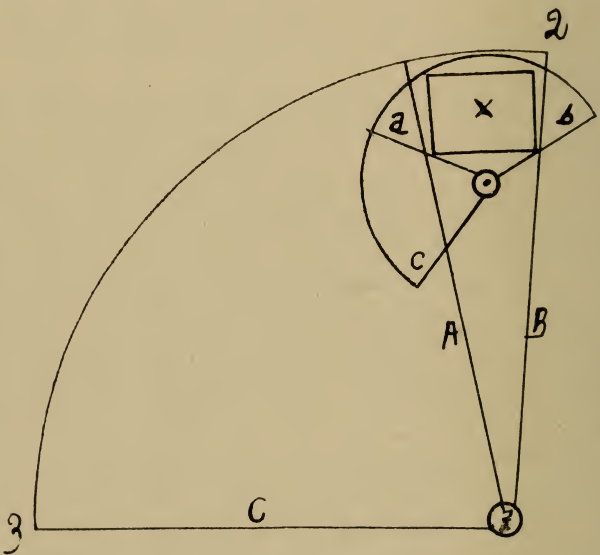


Fig. 101B.

capable of covering opening X during the entire movement of the film. You will observe too, that this blade, instead of occupying more than half the circle, actually covers but a trifle more than one-fourth of it. We will thus be enabled to add two more blades of substantial width, and still cut no more light than would the smaller shutter having but one or two blades.

Fig. 101B contains the meat of the whole shutter matter as applies to the relative merits of inside and outside shutters. It all sums up in the fact that a shutter of very much larger diameter may be used outside, thus allowing of a better arrangement of "flicker blades." Circumferential or peripheral speed is merely an incident. What we call "flicker" is in reality the change from absolute darkness to brilliant illumination of the screen. With a properly proportioned three-wing shutter the screen is totally dark 48 times per second (at normal speed) and 48 times per second it is light. This brings the alternations of light and darkness so close together that the optic nerve does not receive the impression of darkness at all.

With the two-wing shutter the screen is light 32 times per second and dark an equal number of times, which brings the alternations of light and darkness far enough apart that the eye receives a minute impression of darkness, and this is what constitutes the objectionable "flicker" so many times complained of.

Jack a wagon axle up and set one of its wheels revolving rapidly and you cannot see its spokes at all—just a blur. You can look right through the wheel as it revolves. You could even read, with ease, a newspaper held on the opposite side from you. Stop the wheel, however, and remove all the spokes but two—one on each side. You can now hardly revolve the wheel so fast that the two spokes will be invisible. The proposition of the flicker is exactly analogous to the spokes in the wheel. The more spokes you put in, up to a certain point, the less spokes you will be able to see when the wheel is rapidly revolved. The more blades you put into a shutter—that is to say, the more alternations of light and darkness you cause to appear per second, the less darkness (darkness represents the spokes) you will see. This is, however, modified by the fact that the duration of the alternations of light and darkness must be substantially equal to one another if the desired effect is obtained.

WASHING THE GEARS.

Air is usually dusty and it naturally follows that more or less of it settles on the gears of the mechanism, and, combining with the oil, forms a grinding paste which wears out the gears very rapidly. It is, therefore, advisable that the gears be occasionally washed out thoroughly, using kerosene, benzine or gasoline for the purpose. This may be done by removing the machine head, and setting it down bodily in a large can filled with benzine, or it may be done by placing under the gears a shallow pan and washing them with kerosene or benzine contained in an ordinary squirt can, turning the machine crank at the same time. It is a good plan at the same time to squirt gasoline or kerosene into the bearings, thus washing them out thoroughly.

SETTING UP THE MACHINE

No matter from whom you may buy a new machine outfit, it is likely to reach you packed in a box just as it left the factory. Remove the lid of the box, and if there are any screw-heads in the side or end of the box, remove them also. Carefully take out the parts, one by one, unpacking them and laying them aside. Carefully examine every bit of wrapping paper, and be sure it contains no small parts, screws, etc.

After the machine is all unpacked, set up the table or stand first. There are so many different kinds of stands and machine tables that it is not expedient to give explicit directions; moreover, printed directions for setting up should accompany the outfit. Locate the machine as close to the wall of the operating room as you can get it. Be sure the floor of the operating room is solid (see page 70). When the table is in position, put on the lamphouse; clean the condensing lenses and place them in position, and connect the lamp as follows: Locate the operating switch where you want it, either on the wall, in front of the operator, on the under side of the machine table, or, in the case of a machine having an iron pedestal, in the place provided, remembering that if the switch is not contained in an iron cabinet it must be of the enclosed type of switch, i e: one covered with a sheet iron casing. Having located the switch, and, assuming the current to be D. C. and that a rheostat is to be used for resistance, place the rheostat where you want it, and run one wire from one pole of the main operating room switch (not the operating switch, but the operating room switch, the switch at the point where the wires enter the operating room), through fuses, to one binding post of the operating switch. From the other binding post of the main switch run a wire to the other binding post of the operating switch.

One of these wires will be positive and the other wire will be negative, and it is now necessary that we determine which is which, because

The positive wire must be attached to the upper carbon arm of the lamp.

The negative wire must be attached to the lower carbon arm, since otherwise the arc will burn up-side-down, and the light will be very unsatisfactory indeed.

The polarity may be determined in several ways. The simplest one, however, is to run a wire from one binding post of the operating switch to one binding post of the lamp, and run another wire from the other binding post of the operating switch to one (either) binding post of the rheostat and from the other rheostat binding post to the other binding post of the lamp.

At this point it must be remembered that your rheostat must have resistance to correspond to the voltage used, thus: If you have 110 volt current, a 110 volt rheostat must be used, but if you have 220 volt current, then either a 220 volt rheostat or two 110 volt rheostats in series must be used (see resistance). Having carried out the foregoing instructions, place the carbons in the lamp (see carbon setting, page 204), close the main operating room switch and operating switch, and bring the carbons of the lamp together, separating them slightly to form an arc. Let the arc burn for one minute or maybe two, when the carbons will be white hot. Open the operating switch and let them cool.

It will be observed that one carbon is very much hotter than the other and will remain red after the other one has turned black. This carbon (the hottest one) is the positive. If it turns out to be the lower carbon, then take the wires loose, and connect the lower wire to the upper binding post of the lamp, and the upper wire to the lower binding post. With D. C. it is perhaps the better practice to have the rheostat on the positive wire.

If the machine is a combination stereo and moving picture, that is to say, if the stereopticon lens is to be used, attach the extension rods, upon which the lamphouse slides. Some makes of machines, of course, have no extension rods. Next, after carefully cleaning and oiling the mechanism, place it in position and bolt it in place, securing upper and lower magazines in position.

Place your projection lens in the proper place in the mechanism, and your condenser lenses in their casing, first having carefully wiped off the lenses with a soft, very clean cloth or a chamois skin. Next strike an arc and center the light on the screen by raising, lowering or tilting the machine until the picture occupies exactly the space you desire it to be on the curtain, after which, the whole thing should be rigidly secured to the floor (see page 91). If the current is alternating, the directions for connecting would be exactly the same, except that it would make no difference which wire is connected to the top or bottom carbon arm of the lamp, since A. C. has no polarity, or more correctly speaking, both carbons are alternately positive and negative.

This is about all there is to the matter of setting up your machine. Of course, if you use one of the operating room transformers (compensarc, inductor, economizer, etcetera), then you should run both wires from the binding posts of the main operating room switch to the line posts of the transformer, and from the "lamp" post of the transformer directly through the operating room switch to the lamp binding posts. In this connection, however, first look at the directions given under "transformer," page 142, for instructions on the particular type or make of transformer you have. If, on the other hand, you use a Mercury Arc Rectifier, see Mercury Arc Rectifier, page 171, before attempting to make connections.

Let me caution you to be very careful in unpacking your machine not to mislay any of the small parts. It is very seldom indeed that the manufacturer leaves out any parts in packing a machine outfit. The packers are held responsible for such mistakes, therefore, they are very careful. Besides that, the parts are usually checked up by at least two men, so there is not much chance for mistakes of this kind to occur.

THE MACHINE TAKE-UP

Machine take-ups, with the exception of the Motiograph, all operate on the same general plan. In Fig. 101C we see a typical take-up tension device partly disassembled in order to show the various parts, and illustrate its working. 1 is the main spindle 2 is a dog at the end of the spindle which is tripped, as shown

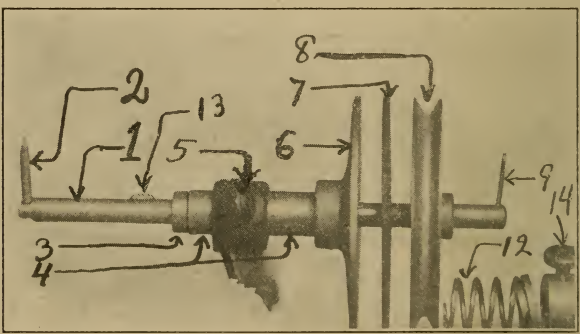


Fig. 101C.

to hold the reel on the spindle. 3 is a collar which is set up against boxing 4, which latter is held stationary in casting 5 by a set-screw. 6 is an iron disk held to shaft 1 by a pin. 7 is a fiber disk (the device illustrated is the Edison take-up), between disk 6 and grooved belt wheel 8. Belt wheel 8 is loose on shaft 1, and may revolve freely regardless of the shaft, but disk 6 is riveted to the shaft and must revolve therewith. 9 is a cotter pin, or "split key," passing through a hole in the end of the shaft. 12 is a spiral spring, and 14 is a collar and set-screw.

The operation is as follows: Spring 12 is placed on shaft 1 at its right-hand end (right-hand in the illustration), and is followed by collar 14, cotter pin 9 being put in its hole to prevent collar 14 from slipping off should thumb screw 14 become loose. Spring 12 presses grooved wheel 8 and fiber disk 7 against iron disk 6. The reel is placed on the opposite end of shaft 1, and is made to revolve by dowel pin 13. Now but for spring 12 holding wheel 8 and fiber disk 7 tightly against iron disk 6, wheel 8 would revolve freely, and shaft 1 and the reel it carries would remain stationary. By reason of the friction between fibre disk 7, grooved wheel 8, and iron disk 6, however, iron disk 6 is made to revolve, carrying shaft 1 and the reel with it. It will be plainly seen that the force which belt wheel 8 will exert on the reel on shaft 1, will be dependent upon how tightly spring 12 forces wheel 8 and fiber disk 7 against iron disk 6, therefore the moving inward of collar 14 with resultant compression of spring 12 increases the lower take-up tension, or in other words, causes belt wheel 8 to pull much harder on the reel than if spring 12 were left comparatively slack. As the film roll gets larger, the reel in the lower or take-up magazine must revolve more slowly, therefore reel 8 slips against fiber disk 7 and this slippage becomes greater as the rewinding progresses. Power's, Standard and Simplex take-ups, while a little different in mechanical construction, operate on exactly the same principle, except that in Power's there is no iron disk 6, but instead belt wheel 8 is itself split, the inner half forming the equivalent of iron disk 6 in the illustration. The Motiograph take-up depends entirely upon the slackness or looseness of its flat belt, as has been already explained.

LINING THE MACHINE

For the best results on the screen, it is essential that the entire optical system, that is to say, the condenser lenses, the aperture and two combinations of the projection lens, be in exact line with each other and with the arc light crater.

In Fig. 101D, A is the arc lamp, B the circular opening in the lamp house for supporting the condensers, but with the condensers removed. D the aperture plate of the machine, E the front plate with the objective removed. F opening in wall of booth, C shows method of applying calipers.

To line up the machine, remove the condensers from their mount and the objective from the machine head. Procure four or five feet of fine wire, and make a loop at one end. Hook this loop over the carbons, exactly where crater on positive carbon is formed, closing the carbons sufficiently to prevent wire from slipping off. Pass the wire through the condenser opening, aperture and objective opening, on through the opening in the wall and draw it up tight, winding the free end as shown at F. The wire can be made still more tense by backing up the arc lamp a little by means of the screw provided for that purpose. Now, by means of rule or calipers, center the wire in the objective opening at E, sliding stick F up, down or sideways until the desired result is accomplished. The tension on the wire should be sufficient to prevent the stick F from slipping out of place. Next, center the wire at B, raising or lowering

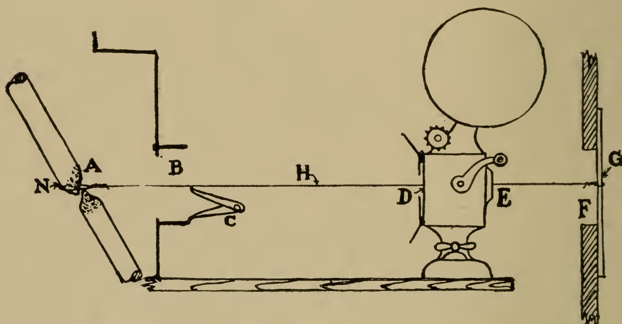


Fig. 101D.

arc lamp to do so. It may be necessary to adjust both B and E simultaneously to gain the best results. When satisfied that B and E are absolutely centered, examine aperture opening, and if everything is O. K. the wire should pass exactly through its center, as may be determined with the calipers. Most likely, though, this will show "out," in which case the machine head should be moved bodily until all openings are directly central with respect to the arc. No attention should be paid to opening in wall of booth, as this has nothing to do with the lining up of the machine itself. If it is known how far apart the carbons are drawn when running the lamp regularly, a small notch could be filed in the upper carbon at N, directly opposite the crater, to hold the loop in the wire, and then the carbons drawn apart to their working distance when making all the above measurements.

The Edison Kinetoscope.

INSTRUCTIONS FOR MODEL B

No. 1.—To Remove Adjusting Lever, 18047, P 1, unscrew same from adjusting gear shaft, 18052, P 2, by turning to the left several times.

No. 2.—Driving Crank, 18066, P 1, is secured to shaft by means of a spring catch and is readily released by pressing on the spring.

No. 3.—To Remove Adjusting Gear Shaft, 18052, P 2, and brackets, 18057 and 18058, P 2. Remove screws (four of them), 17585, P 2, which releases the entire bracket. To further take apart, or adjust, loosen collar set screws, 2798, P 2, which allows bracket, 18057, P 2, and adjusting screws, 2076, P 2, to be slipped off the shaft, after adjusting gear, 18049, P 2, has been loosened by means of driving out the straight pin which holds it to the shaft. Bracket 18058 also may be slipped off the shaft.

No. 4.—To Remove Gate, Together with the Assembled Parts Thereon. The gate is removed from mechanism by taking out hinge rod, 18193, P 1. If the gate sticks, tap gently until released.

No. 5.—Gate Guide Roller, 18204, P 2, and flanges, 18205, P 2, may be removed by driving out guide roller shaft, the part number of which is 18206. Use a punch and drive the shaft out toward the hinges of the gate.

No. 6.—Upper Film Guard, 18757, P 1, may be removed by taking out screws (two of them) 2798, P 2, on inside of guard. Do not attempt to remove the upper guard by removing screws, 20636, P 1, as they have nothing to do with the guard.

No. 7.—Gate Latch, 18758, P 1, may be removed by taking out latch screw, 20406, P 1, and upper gate stop screw and nut, 2782 and 18207, P 1.

No. 8.—Automatic Fire Shutter is removed by loosening screw 18779, P 1, and taking off collar, 18778, P 1. Next, loosen screw, part number of which is 8132, in the side of part 18789, P 1 (part 18789 is the nickelplated hub). This hub is a part of the clutch disc which holds the governor weights. You may then pull out shaft and mitre gear, 19411, P 2. The cover, 18791, P 1 and 3, may be lifted off by removing two flat head screws, 1841, P 1 and 3.

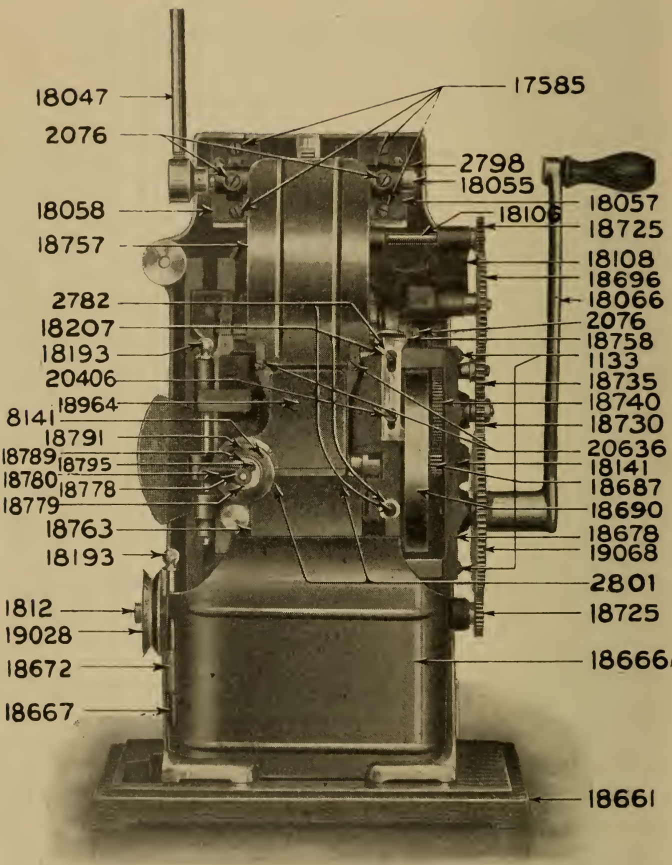


Plate 1.
Fig. 102

Having removed the shutter from the gate, you will see, on the inner end of the hub in which was shaft 18411, P 2, a brass collar. This collar is merely pressed on the hub, and is held there by friction alone. It can be pried off or removed with a pair of gas pliers. Having removed this collar, which is part No. 18785, you can lift off the shutter blade and weight, thus revealing a spider-shaped copper spring. This spring is for the purpose of holding the shutter blade away from the revolving mechanism after the shutter is locked open, thus eliminating considerable friction which would otherwise be present. It will be noticed that three of the prongs of the spring are bent upward, and three are flattened out against the metal. This is as it should be, since the spring must provide friction between the revolving part and the shutter blade part until the shutter blade has been raised. Do not bend the prongs, but leave them as you find them. This spring should be examined once in a while, since it will naturally develop some wear, which has the effect of allowing the metal revolving part to rub too hard against the shutter blade, thus causing undue friction. The governor may be still further disassembled by removing screws (two of them) 18795, P 1 and 3, which are in the head of the nickel-plated hub of the clutch disc, 18789, P 1. These two screws have on their circumference small spiral springs, the part number of which is 18796. Be careful and do not lose these springs. Their use and purpose is as follows: When the semi-circular weights, which you will see when the cover is removed, spread open through centrifugal force, the part carrying the shutter blade is forced outward, toward the gate against the pressure of these springs, by the two little arms or levers on their inner ends. This has the effect of locking the fire shutter open when the machine has attained speed, so that all friction is removed. When the speed drops below the danger point, these leaden weights fall inward and the two little springs pull the central metal part, carrying the shutter blade inward again, thus unlocking shutter blade and allowing it to fall and shut off the light from the film.

No. 9.—Bracket, 18780, P 1, which carries the outer end of mitre gear shaft, 19411, P 2, may be removed by taking out one screw, the part number of which is 17587, which holds the foot of the bracket to the casting of the gate. *Caution:* The bracket is held square by two dowel pins, the part number of which is 18782, in addition to the screw. Be careful and do not bend these pins or you will have trouble.

No. 10.—Lower Guard, 18763, P 1, is removed by taking out two screws, 2801, P 1.

No. 11.—Lower Film Protector, 18666, P 1, and its support,

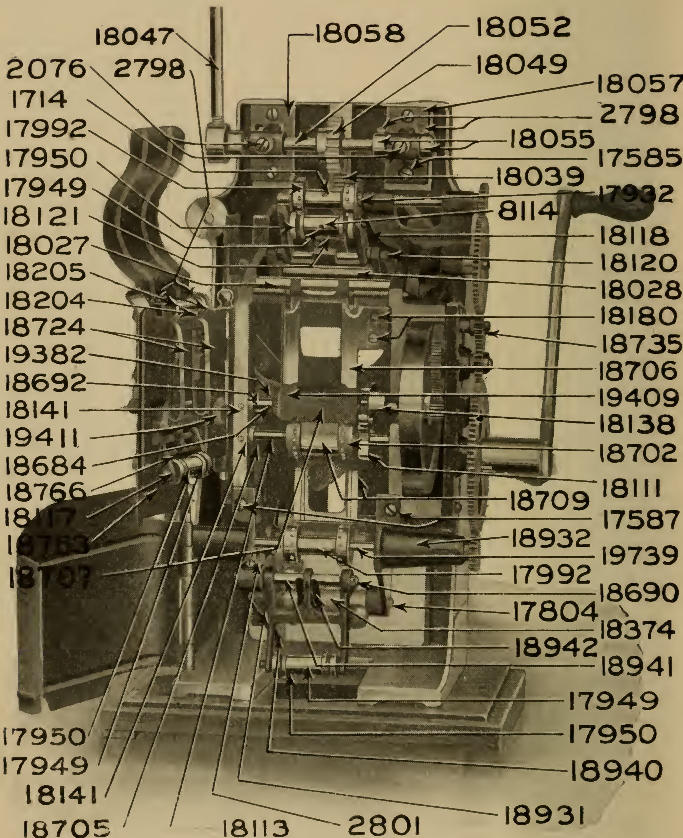


Plate 2.
Fig. 103

or hinge, 18667, P 3, may be removed by taking out screws (three of them) 2798, P 3.

No. 12.—Spring, 18672, P 3, may be removed by taking out hinge rod 18193, P 3. This also releases lower film protector, 18666, P 1. To replace film protector, 18666, P 1, its hinge rod, 18193, P 3, and spring, 18672, P 3, remove hinge, 18667, P 3, and replace the spring and hinge rod, afterwards readjusting the hinge, with its assembled parts, to the machine frame. The spring in question can be put back without taking off the hinge, but this is very difficult to do.

No. 13.—Gate Idler Roller, 17950, P 2 (end), and 17949 (body), P 2, may be removed by loosening the set screw in 17949, P 2. Gate idler roller bracket, 18766, P 2, and the spring which supplies tension to the bracket, may be removed by driving out shaft 18117, P 2, which holds same. To replace the spring which this shaft carries, place the spring in a straddling position over the center part of the roller bracket, with the two ends of the spring at the bottom, and the loop shaped part on top. Place the spring in the groove in the casting and press the bracket and spring down simultaneously, pushing the shaft through the bracket and spring and into its bearing at the other end, while holding the spring and bracket down with the other hand.

In case the spring does not exert sufficient pressure, grasp the loop at the top with a pair of pliers and pull it outward. This will have the effect of making the spring stronger in its action. See to it that the coils of the spring are close to the central portion of the bracket.

No. 14.—Mechanism Base, 18661, P 3, is held by four flathead screws which may be removed by turning the machine upside-down.

No. 15.—To Remove Take-up Sprocket Shaft, remove pulley, 19028, P 1 and 3, by driving out taper pin in its hub, being careful to drive it in the right direction or you will simply succeed in making the pin tighter, instead of removing it. If the machine is of the outside shutter type, then this pulley will be a chain pulley, as seen in P 4, and will be held to the shaft by a screw. Next loosen the screw in the hub of take-up sprocket 17992, P 2, and the shaft, 19739, P 1, and pinion, 18725, P 1, may be pulled out to the right. There is, or may be, a washer between pulley, 19028, P 1, and the boxing. Don't lose it and be sure to get it back in reassembling the parts. Back the screw in sprocket hub out considerably, as it is counter-sunk.

No. 16.—Upper Sprocket, Shaft, Pinion and Bracket. In order to remove shaft, 18106, P 1, and pinion, 18725, P 1, loosen

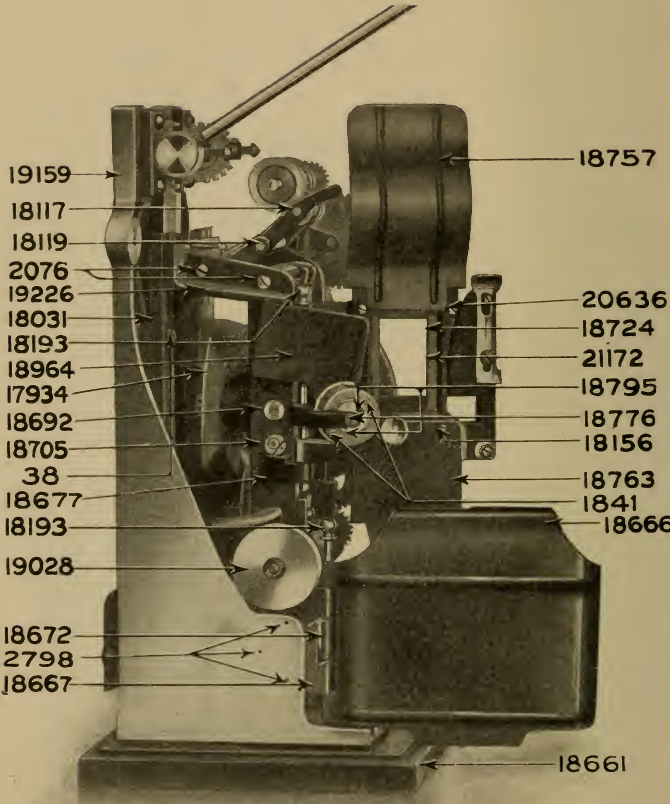


Plate 3
Fig. 104

set screw, 1714, P 2, in hub of upper sprocket, 17992, P 2, and remove same from shaft. Between the sprocket and the inner bearing of the shaft, will be seen set collar, 17932, P 2. Loosen the screw in this collar, after which the shaft and pinion can be pulled out from the gear side.

No. 17.—The Cast Iron Bracket Carrying Shaft, 18106, P 1, and gear, 18696, P 4, may be removed by taking out screws (2 of them), 2076, P 5. It may be necessary to carefully pry the bracket, off after removing the screws.

No. 18.—To Remove Upper Tension Bracket, 18118, P 2, drive out the spindle which holds it, first having loosened the two screws which hold the flat spring bearing on the bracket. The idler 17950, P 2, may be removed from the bracket by loosening set screw, 8114, P 2, in its center, and driving out the spindle.

No. 19.—To Remove Large Intermediate Gear, 18696, P 1, and second intermediate gear, 18735, P 1, it is only necessary to take out cotter pins, the part number of which is 18090, which hold them to their stud. Large driving gear, 19068, P 1, is held by a screw and washer, and may be removed by taking out the screw, the part number of which is 17804.

No. 20.—Cam Shaft Driving Gear, 18740, P 1, and first intermediate pinion and its shaft, 18730, P 1, may be removed only after frame side cap, 18678, P 1, which is held by screws (2 of them), 1133, P 1, has been taken off. This cap is also held by two dowel pins, part number of which is 18025. It will probably be necessary to carefully pry the frame cap away after removing the screws. After the cap is removed the part may be taken off by driving out taper pin in the hub of first intermediate pinion, 18730, P 1, tapping it gently with a punch, if necessary.

No. 21.—Cam Shaft Bearing (long), 18691, which is in frame cap, 18678, P 1, just below gear, 18740, P 1, may be removed by loosening set screw, 18141, P 1, first having taken off the frame cap, as per instruction No. 20.

No. 22.—Tension Springs, 18724, P 2, can be removed by taking out the two screws, the part number of which is 8424, which holds them. More tension may be supplied by inserting a screwdriver blade under the spring and running it up and down a few times, at the same time pulling outward. Be careful, however, and do not overdo this or you will either break the spring or provide too much tension, which is, in another way, just as bad as not enough.

No. 23.—To Remove Aperture Plate, 18706, P 2, take out screws, 18180, P 2. Behind the aperture plate is upper film-guard, 18707, P 2, which may then be removed by driving out film-guard pin, 18187, P 4.

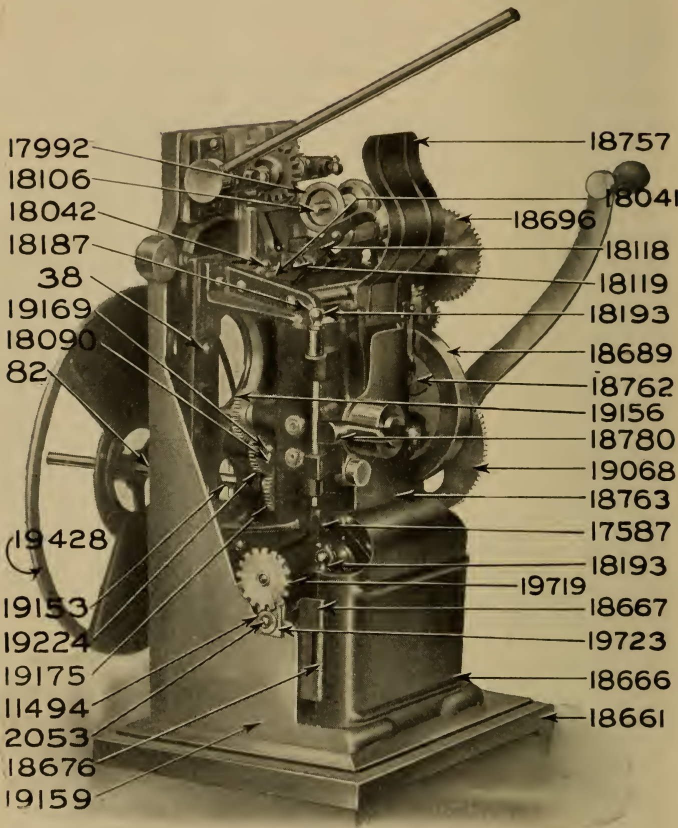


Plate 4

Fig. 105

No. 24.—To Remove Cam Shaft, 18684, P 2, and the parts assembled thereon, first proceed as per instructions Nos 23 and 20. Next loosen set screw holding cam shaft bushing, 18692, P 3, and slip the bushing out. The shaft and its assembled parts, including mitre gear, cam, balance wheel and pinion may then be lifted away.

No. 25.—Mitre Gear, 19409, P 2, may be removed by following instruction No. 24, after which drive out the taper pin, part number of which is 18683, holding the gear to the shaft. It will be necessary to force the gear from the shaft, using a copper or other soft punch and resting the end of the shaft on a block of wood.

No. 26.—To Remove Cam, 18138, P 2, follow instructions No. 24 and 25. Then drive out the pin in the flat surface of the side of the cam, which releases it from the shaft, and it may be driven off.

The re-assembling of these parts is merely a matter of reversing the process of their dis-assembling.

No. 27.—To Remove Intermittent Shaft, 18113, P 2, and its assembled parts, take off lower film guard (apron), 18709, P 2. The same is held by two screws at its lower end. Next loosen set screws (2 of them), 18141, P 1 and 2, and remove eccentric bushings, 18705, P 3 and P 5. The shaft and its assembled parts, including the intermittent sprocket and star may then be lifted away.

No. 28.—The Star, 18111, P 2, may be removed from its shaft by following instructions No. 23 and 27, and then driving out the taper pin, part number of which is 18172, from its hub.

No. 29.—Intermittent Sprocket, 18702, P 2, may be removed from its shaft by following instructions Nos. 23 and 27, and then driving out the two pins which hold the same. In finishing these parts it sometimes occurs that the pins are not visible without close examination. You are cautioned, therefore, to look closely. Force sprocket off opposite end from star, as this end of the shaft is slightly smaller in circumference.

No. 30.—The Revolving Shutter Shaft and Mitre Gear. In order to remove mitre gear, 19382, P 2, and its shaft, revolving shutter, 17934, P 3, must be taken off. Follow this up by removing cam shaft as per instruction No. 24, and the mitre gear and shaft can then be pulled out of its bearings. This applies to the inside shutter machine only. The outside shutter bevel gear and shaft may be removed in the same manner, however, except that the gear on its inner end is held in place by two screws which must be loosened.

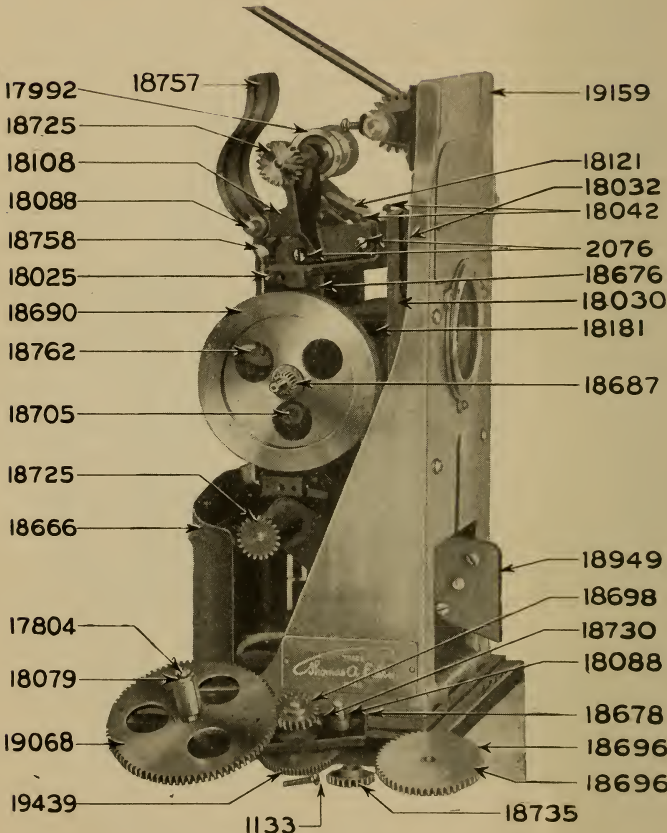


Plate 5
Fig. 106

No. 31.—The Entire Mechanism, that is to say, the part which frames up and down, may be removed from the frame by taking out the mechanism holding screws (4 of them), one of which is shown at 38, P 3 and 4, the other three being in corresponding positions, there being two on one side and two on the other. These four screws hold the mechanism to the frame.

No. 32.—The Take-up Casting, 18932, P 2, carrying the lower or take-up sprocket and its shaft, and to which is also attached the take-up arm, may be removed by taking out two screws, 17587, P 2.

No. 33.—Aperture Plate, 18706, P 2, is supported by aperture plate bracket, 18181, P 5. This bracket is held in place by two bracket screws, part number of which is 18182. It sometimes happens that these screws work loose, in which case the aperture may vibrate, or may get out of place, and trouble will be produced on the screen. The remedy, of course, is to tighten the two screws. The screws supporting this bracket are in slotted holes and the position of the aperture can be shifted side-wise to a very considerable extent by loosening these screws. Should a picture at any time suddenly appear out of level on the screen, it is very likely that these screws have worked loose.

No. 34.—The Revolving Shutter Shaft, carrying mitre gear, 19382, P 2, is carried by a bushing, the number of which is 19225. This bushing is readily removed by loosening the set screw in the side of the casting which holds it in place, first, of course, having removed the shaft as per instruction No. 30.

No. 35.—To Remove Lower Sprocket Idler Bracket, 18940, P 2, loosen screw 2801, P 2, and the shaft, bracket and idler may all be pulled out. When you put the idler back, just slip the shaft, 18941, P 2, into place, allowing the idler to rest on the sprocket, and tighten up screw 2801. This will supply the required tension to the idler. If trouble is experienced with the film pulling over the sprocket, thus losing the lower loop, see to it that screw 2801, P 2, is set up tight, since otherwise the idler would not be held down on the sprocket by tension spring 18942, P 2.

No. 36.—Sprocket Teeth. See general instruction Nos. 3 and 8. The wise operator will have in his possession a complete extra cam shaft, with balance wheel, balance wheel pinion, cam and mitre gear, assembled thereon, as shown at B, Fig. 107, all ready to slip into the machine on short notice. He will also have a complete star shaft, with intermittent sprocket and star assembled thereon, as shown at A, Fig. 107, ready to slip into the machine. By this method, should anything go wrong with the intermittent movement, it is a matter of a few moments to re-equip the machine with a new cam, or a new star, by slipping out the old part and installing the new. This plan has a further advantage that, instead of trying to install a new cam, star, or intermittent sprocket on the shaft, a job usually somewhat difficult of proper accomplishment outside of the factory, one can send the parts to the factory by registered mail and have them put on

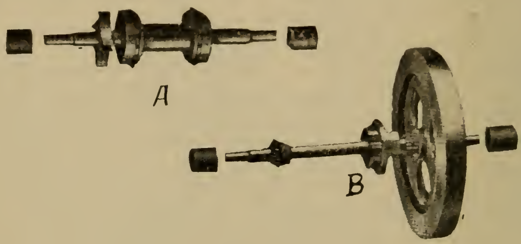


Fig. 107

right. All operators are strongly advised to have these extra parts. It will save you much vexation and trouble, as well as being cheaper in the long run. The operator should, of course, also have extra bushings for both the cam and star shaft. It does not pay from any point of view to use worn sprocket teeth, particularly the intermittent sprocket teeth, or a badly worn cam, or star.

No. 37.—Setting the Shutter. To set outside revolving shutter, 19428, P 4, place shutter on its shaft with hub towards the mechanism. Have the lens in focus and place the shutter as close as possible without having its blades strike the lens. About one-quarter of an inch away will be right. Tighten up the set screw in shutter-hub, which engages with the groove in the spindle.

The Two-Wing Outside Shutter. To set the two-wing outside shutter proceed as follows: Place a piece of film in the machine. Loosen the three clamp screws on the front of the shutter, just enough to be able to turn the blade when the hub is held stationary. Now set one blade (either one) so that it covers the lens during the time the film is in motion. This can be determined either by looking through the aperture, by watching the intermittent sprocket, or by leaving the dowser down, lighting the arc light and allowing the light to filter through the mica dowser cap, which will, when the fire shutter is raised, project the picture to the screen, sufficiently plain for the purpose. After the blade is so set that no movement of the film is visible while any portion of the lens is uncovered, tighten up the clamp screws again, and the job is done.

The Three-Wing Outside Shutter.—The three-wing outside shutter is set the same as is the two-wing, except that the wide blade is the one which cuts off the light. No attention need be paid to the other two blades, nor to the second blade on the two-wing shutter; they being merely a combined counter-balance and flicker blade.

The Inside Shutter.—The inside shutter is set in exactly the same manner as is the outside, except that there are two set screws in the shutter hub, the loosening of which allows of the shutter being revolved on its shaft. No attention need be paid to the perforated shutter blade.

NAMES AND NUMBERS OF PARTS FOR THE EDISON MODEL B. MECHANISM

Order Parts by Number. These Numbers Are the Manufacturer's Regular Stock Numbers.

LIST OF PARTS SHOWN ON PLATE NO. 1.

18047 Adjusting Lever.
2076 Adjusting Gear Shaft Friction Screw.
18058 Adjusting Gear Shaft Friction Bracket (left).
18757 Gate Upper Guard.
2782 Gate Stop Screw (upper and lower).
18207 Gate Stop Screw Nut (upper).
18193 Gate Hinge Rod.
20406 Gate Latch Screw.
18964 Automatic Drop Shutter.
8141 Automatic Drop Shutter Clutch Cover Screw.
18791 Automatic Drop Shutter Clutch Cover.
18789 Automatic Drop Shutter Clutch Spider.
18795 Automatic Drop Shutter Clutch Disc Screw.
18780 Automatic Drop Shutter Clutch Shaft Bracket.
18778 Automatic Drop Shutter Clutch Shaft Collar.
18779 Automatic Drop Shutter Clutch Shaft Collar Set Screw.
18763 Automatic Gate Lower Guard.
18193 Automatic Gate Hinge Rod.
1812 Take-up Sprocket Shaft Pulley Pin.
19028 Take-up Sprocket Shaft Pulley
18672 Film Protector Spring.
18667 Film Protector Hinge.
17585 Adjusting Gear Bracket Screw.
2798 Adjusting Gear Shaft Collar Set Screw.
18055 Adjusting Gear Shaft Collar.
18057 Adjusting Gear Shaft Bracket (right).
18106 Upper Sprocket Shaft.
18725 Upper Sprocket Shaft Pinion.
18108 Upper Sprocket Shaft Bracket.
18696 Large Intermediate Gear and Hub.
2076 Frame Side Post Screw.
18758 Gate Latch.
1133 Frame Cap Screw.
18735 Second Intermediate Pinion.
18740 Cam Shaft Driving Gear.
18730 First Intermediate Pinion.
20636 Film Gate Upper Guard Stop Screw.
18141 Cam Shaft Bearing Set Screw.
18678 Frame Slide Cap.
19068 Large Driving Gear with Sleeve and Pins.
18725 Take-up Sprocket Shaft Pinion.
18661 Mechanism Base.
18066 Crank.
18687 Cam Shaft Pinion.

LIST OF PARTS SHOWN ON PLATE NO. 2.

18047 Framing.
1714 Upper Sprocket Set Screw.
17992 Upper Sprocket.
8114 Upper Tension Roller Body Set Screw.

17950 Upper Tension Roller End.
17949 Upper Tension Roller Body.
18121 Upper Tension Roller Springs.
18027 Frame Side Post (long plain).
18205 Guide Roller Flange.
18204 Guide Roller.
18724 Film Tension Springs.
19409 Cam Shaft Mitre Gear.
19382 Revolving Shutter Shaft Mitre Gear.
18692 Cam Shaft Bearing (short).
18141 Cam Shaft Bearing Set Screw.
19411 Drop Shutter Clutch Shaft Mitre Gear.
18684 Cam Shaft.
187666 Gate Idler Roller Bracket.
18177 Gate Idler Roller Shaft.
18763 Gate Lower Guard.
17950 Gate Idler Roller End.
17949 Gate Idler Roller Body.
18141 Star Shaft Eccentric Bearing Set Screw.
18705 Star Shaft Eccentric Bearing.
18113 Star Shaft.
2801 Take-up Tension Roller Bracket Shaft Screw.
18931 Take-up Frame Side (large).
18940 Take-up Tension Roller Bracket
17950 Take-up Tension Roller End.
17949 Take-up Tension Roller Body.
18039 Slide Adjusting Rack.
18106 Upper Sprocket Shaft.
18725 Upper Sprocket Shaft Pinion.
18696 Large Intermediate Gear.
18028 Frame Side Post (short).
18180 Aperture Plate Screws (2).
18706 Aperture Plate.
18138 Cam.
18111 Star.
17587 Take-up Attachment Screw.
18725 Take-up Sprocket Shaft Pinion.
18932 Take-up Frame Side (small).
18702 Intermittent Sprocket.
18709 Lower Film Guard.
17804 Take-up Frame Side Post Screw
19739 Take-up Sprocket Shaft.
18690 Take-up Tension Roller Bracket Shaft Cotter Pin.
17992 Take-up Sprocket.
18374 Take-up Roller.
18942 Take-up Tension Roller Spring.
1894 Take-up Tension Roller Bracket Shaft.

LIST OF PARTS SHOWN ON PLATE NO. 3.

19159 Mechanism Support.
18117 Upper Tension Roller Shaft.
18119 Upper Tension Roller Bracket Pin.
2076 Frame Side Post Screw.
19226 Frame Side (left).
18193 Gate Hinge Rod.
18031 Body Slide (left).
38 Mechanism Holding Screw.
18964 Automatic Drop Shutter.
17934 Revolving Shutter (inside).
18692 Cam Shaft Bearing (short).
18705 Star Shaft Eccentric Bearing.
18193 Film Protector Hinge Rod.
19028 Take-up sprocket shaft pulley.
18672 Film Protector Spring.
18667 Film Protector Hinge.
18757 Gate Upper Guard.
20636 Gate Upper Guard Stop Screw.
18724 Tension Spring.
21172 Tension Spring Screw.
18776 Automatic Drop Shutter Clutch Shaft.
18156 Gate Lower Guard Screw.
18763 Gate Lower Guard.
18666 Film Protector.
18661 Mechanism Base.
2798 Film Protector Hinge Screw.

LIST OF PARTS SHOWN ON PLATE NO 4.

17992 Upper Sprocket.
18106 Upper Sprocket Shaft.
18118 Upper Sprocket Roller Bracket.
18042 Slide Adjusting Bracket Screw.
18119 Upper Tension Roller Bracket Pin.
18187 Upper Film Guard.
38 Mechanism Holding Screw.
19156 Outside Revolving Shutter Driving Gear.
19169 Outside Revolving Shutter Intermediate Gear Stud.
82 Outside Revolving Shutter Set Screw.
18090 Revolving Shutter Intermediate Gear Cotter Pin.
19224 Revolving Shutter Intermediate Gear.
19153 Outside Revolving Shutter Shaft.
19175 Revolving Shutter Shaft Gear.
17587 Take-up Attachment Screw.
2076 Frame Side Post Screw.
19428 Outside Revolving Shutter Blade with Holder.
1494 Driving Chain Tension Link Screw Washer.
2053 Driving Chain Tension Link Screw.
19129 Mechanism Support.
18757 Gate Upper Guard.
18696 Large Intermediate Gear.
18066 Crank.
18193 Gate Hinge Rod.
18762 Gate Latch Catch.
19068 Large Driving Gear with Sleeve and Pins.
18780 Automatic Drop Shutter Shaft Bracket.
18763 Film Gate Lower Guard.
18193 Film Protector Hinge Rod.
19719 Driving Chain Upper Sprocket with Hub.
18667 Film Protector Hinge.
19723 Driving Chain Tension Link.
18666 Film Protector.
18661 Mechanism Base.
18689 Balance Wheel.

LIST OF PARTS SHOWN ON PLATE NO. 5.

17992 Upper Sprocket.
18725 Upper Sprocket Shaft Pinion.
18108 Upper Sprocket Shaft Bracket.
18088 Large Intermediate Gear Stud.
18758 Gate Latch.
18025 Frame Cap Dowel Pin.

18690 Balance Wheel with Cam Shaft Pinion.
18762 Gate Latch Catch.
18705 Star Wheel Shaft Eccentric Bearing.
18725 Take-up Sprocket Shaft Pinion.
18666 Film Protector.
17804 Large Driving Stud Screw.
18079 Large Driving Stud Washer.
19068 Large Driving Stud with Sleeve and Pins.
19439 Cam Shaft Driving Gear.
19159 Mechanism Support.
18042 Slide adjusting rack ratchet screw.
2076 Frame Post Screw.
18949 Take-up Frame (large).
18703 First Intermediate Pinion Pin.
18730 First Intermediate Pinion.
8088 Second intermediate pinion stud.
18678 Frame Side Cap.
18696 Large Intermediate Gear.
18089 Second Intermediate Pinion Stud Collar.
18735 Second Intermediate Pinion.
1133 Frame Cap Screw.
18687 Cam Shaft Pinion.

The Motiograph

INSTRUCTIONS FOR THE 1912 MODEL

NO. 1.—Gear Cover, 3A, P 1, may be removed by loosening thumb screws, 231 and 232, P 3, and 233, P 5. The cover may then be lifted away exposing the gears, flywheel and automatic fire shutter governor.

No. 2.—The Whole Mechanism can be swung around on its base by loosening the hand wheel bolt underneath baseboard slightly, then raising pin, 283, P 1.

No. 3.—Front Plate, 172, P 4, is removed by loosening thumb screws (two of them), 99A, P 4, and lifting spring, 275, P 4, at the same time pulling top of front plate forward. It may then be lifted off of screws 99A, P 4.

No. 4.—The Gate Is Opened by pressing on knob, 125, P 1, This knob is the end of the gate-latch rod, which extends across the machine, as may be seen by removing front plate 172, P 4, see instruction No. 3, and looking inside the mechanism. Gate-latch screw No. 220, P 1, is threaded into this rod, and may be removed with a screw driver. On the inner end of the gate-latch rod 125, P 1, is a spiral spring. To remove this spring it is necessary to remove rod 125, P 1. To remove this rod, first take out gate-latch screw 220, P 1. Next remove the front plate 172, P 4, see instruction 3, and, looking inside the machine, you will see, on the rod, against the casting at the left-hand side, a brass collar held in place by one set-screw. Loosen this set-screw and the whole rod may then be pulled out. To replace same, insert rod in its hole, on left-hand side, then slip first the collar, and then the spring on the rod, and enter the end of the rod in its hole on the right-hand or gear side. Put the latch in and shut gate; then set the collar up snugly against the casting on left-hand side, tightening its set-screw, and the job is done.

No. 5.—To Remove Gate, take out ball screws, 127, P 1, and 127, P 3, which act as the gate hinge. Lift the rack-bar, 168, P 1, off governor crank shaft, 83, P 1. Gate may then be lifted away. In replacing same, do not forget to connect rack-bar, 168, P 1, and governor crank shaft, 83, P 1.

No. 6.—The Aperture Plate, 162A, P 3, is removed by taking out screws (four of them), 217, P 3. The screws are small, therefore be careful or you will lose them. Better lay a piece of paper underneath first to catch them should they fall.

No. 7.—Tension Springs and Shoes. The tension shoes, 96A, P 3, are held in place by tension spring, 174A, P 1, which is one piece, and also applies pressure to the shoes. Both the shoes and spring may be removed for adjustment or replacement as follows: (a) Remove gate as per instructions, 3; (b) loosen screw, 294½, P 2, and swing cooling plate, 97A, P 2, out of the way, then raise fire shutter, 163, P 1; (c) remove the two screws, 221 P 1, which releases both the shoes and spring, which may now be removed. In removing same, note carefully how the spring locks into the shoes. If a tighter tension is required it may be obtained by bending both ends of spring, 174A, P 1, down slightly so that when replaced the center of spring where screws, 221, P 1, enter, will be higher than the ends. The more the spring is bent, the tighter the tension will be. If less tension is required bend spring the opposite way from the above instruction. In replacing same it matters not which shoe goes on the right or which goes on the left side, but the notches in which the spring fits must point downward. The side of spring, 174A, P 1, marked "Patent applied for" goes out—that is to say, the other side goes toward the gate.

No. 8.—To Remove Upper Sprocket, 106, P 5, remove (not loosen, but remove) screw 204, P 5. The sprocket may then be pulled off, and its shaft, 51A, P 5, may be pulled out to the left, first having removed gear cover (see instruction No 1). In replacing the sprocket the end with an off-set hub goes inside against the casting hub; if put on the other way, the sprocket will be out of line with aperture.

No. 9.—Upper Sprocket Idler Bracket, 24, P 5, may be removed by (a) loosening screws, 227 and 265, P 5, and removing screw, 249, P 5. The whole may then be pulled out. Let it be understood that when the instruction says remove a screw, *remove* it; loosening it will not do. It must be taken out entirely.

Idler roller, 108, P 5, is held away from the sprocket by screw, 241½, P 5, which is locked by lock-nut, 241, P 5. Idler roller, 108, P 5, may be removed from its spindle by taking out screw, 223, P 5.

No. 10.—Lower Sprocket, 106, P 5, may be removed by taking out screw in hub of sprocket. If it is also desired to remove its shaft, 52A, P 4, carrying belt pulley, 20, P 1, it will first be necessary to follow instructions Nos. 16 and 19. Having done so you will see, down in a pocket inside the frame casting,

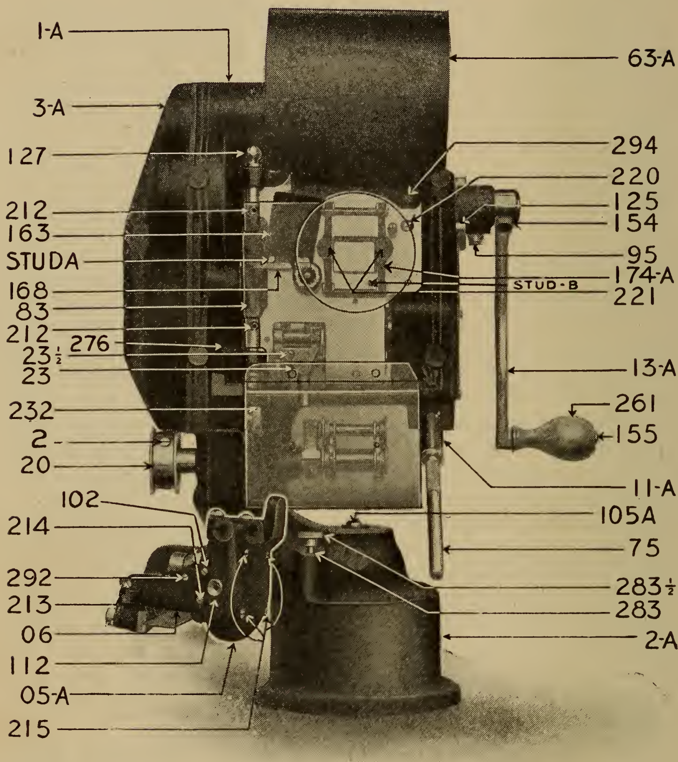


Plate I
Fig. 108

gear, 17A, P 2, which drives shaft, 52A, P 4. Loosen the set-screw in the hub of this gear, which is deeply countersunk into the shaft, hence must be backed out for some distance, and the shaft may then be pulled out. In replacing same, be sure you get set-screw which holds gear, 17A, P 2, properly located in its countersink in the shaft.

No. 11.—Framing Lever Casting, 11A, P 3, may be removed by removing screw, 76, P 3.

No. 12.—Lower Idler Bracket, 25A, P 5, may be removed by: (a) follow instruction No. 11; (b) remove lower sprocket, 106, P 5, as per instruction No. 10; (c) remove screw, 249, P 5 (screws 227, 249 and 265 have same numbers for both upper and lower bracket); (d) loosen screws, 227 and 265, P 5; (e) slacken off on screw, 241¾, P 5, until head of center roller will pass the drop in the casting on the left, the bracket may then be slipped out. In replacing same, be sure to set screws, 265 and 227, P 5, up tightly, and adjust screw, 249, until the proper tension of bracket is obtained, this should be just tight enough to keep the film in position on lower sprocket at all times. Adjust screw, 241¾, P 5, so that the top and front roller will set away from the sprocket by twice the thickness of a film. The shaft of the rear roller, 108, P 3, is on an eccentric and may be adjusted to the proper distance from sprocket by loosening screw, 25½, P 3, and turn same with a screw driver by means of screw, 223, P 5, of rear roller.

No. 13.—Shutter Blades, 170A and 171A, P 5, may be removed by: (a) loosening the two screws in hub of outer leaf, 170A, P 5, and pulling same from its spindle, 38A, P 5 and 7. The inner half 171A, P 5, may then be removed by taking out the three flat-head screws, 48A, P 7, in the face of its brass hub on gear 46A, P 7.

No. 14.—Shutter Driving Gear, 45A, P 5, and its mate, 46A, P 7, on shutter shaft, 38A, P 5 and 7, may be removed as follows: (a) Remove shutter blades as per instruction No. 13; (b) remove the small screw 41A, P 5, in center of face of gear, 45A, P 5; (c) remove the bridge as per instruction No. 13, and pull out the shutter drive shaft and gear, 287, P 2. This will release gear 45A, P 5. The gear 46A, P 7, into which gear 45A, P 5, meshes, same being on shutter spindle 38A, P 5, may then be removed as follows: (a) Remove aperture plate as per instruction No. 4 and, looking in through the hole, you will see two screws, 206A, P 7, in the hub of the gear 46A, P 7, behind the inner shutter blade. Loosen these and the gear may be slipped off.

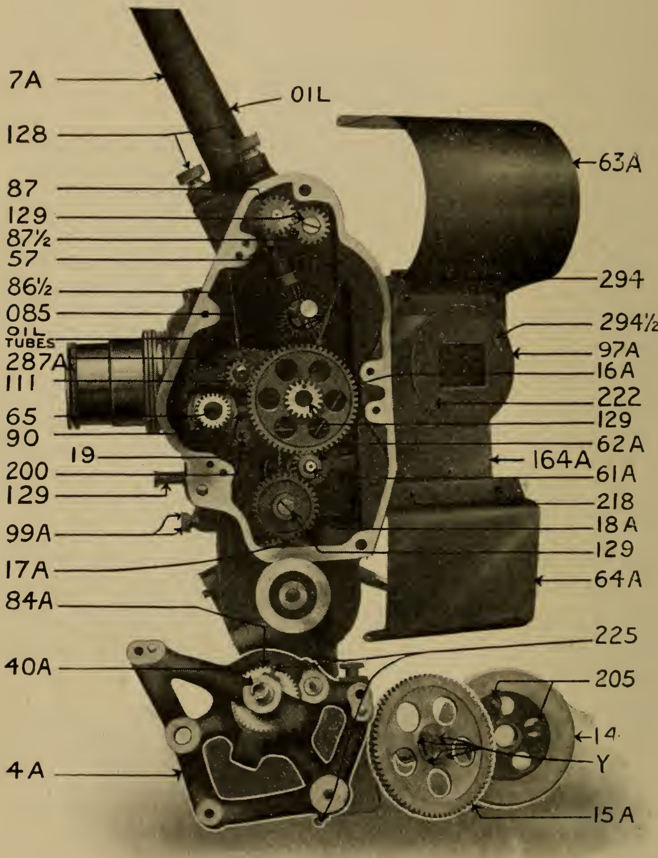


Plate 2

Fig. 109

No. 15.—After removing gear 45A, P 5, and its mate, 46A, P 7, as per instruction No. 14, you will see the face of a brass boxing about one inch in diameter, from which projects shutter spindles, Nos. 38A and 39A, P 5 and 7. In its face is a screw. Don't touch this screw, as it is the head of a small spindle, the brass boxing being in reality a casing and boxing combined, inside of which are four small gears. It is not advisable that the operator attempt to make any repairs on this device. It is extremely unlikely that anything will ever happen to it, and if kept properly lubricated it is subject to very little wear. However, should you find that one shutter blade can be moved considerably circumferentially, while the other is held stationary, it is evidence of wear in the gears or spindles inside the brass casing, although more or less play will be in evidence even in the new ones, owing to the number of gears necessary to revolve the two-shutter wings in opposite directions. You can order another complete casing from the factory—that is to say, with the gears, etc., assembled therein—and remove the old one as follows: (a) Follow instructions 13, 14, 16 and 28. You will then see the back end of the shutter gear casing 288, P 7. Into the top of its circumference is screwed a flathead machine screw No. 93A, P 7; a larger one 92A, P 7, is at the bottom screwed into main frame. Remove screw 93A, P 7, and shove the whole casing out on the shutter side. It is unnecessary to touch screw 92A, P 7, to remove casing. Insert the new casing, replace screw 93A, P 7, and screw it up gently. If screwed too tight the head of screw is liable to break off. This will bring the gear casing back into position against the head of screw No. 92A, P 7; replace gear 46A, P 7, push it on as far as it will go and tighten screws 206A, P 7, replace shutter drive shaft and gear No. 287, P 2, then replace gear 45A, P 5, being sure to engage the tongue on the steel plate in the center of gear 45A, P 5, with the groove of the same size on shaft 287, P 2, and replace screw 41A, P 5, and screw it up tight. The teeth of the two gears 45A, P 5, and 46A, P 7, should now mesh properly; that is, the teeth of the two gears should be flush with each other. If the gear 46A, P 7, extends into the shutter side of mechanism too far, so that the teeth on it extend over the teeth of gear 45A, P 5, it may be drawn back by loosening screw 92A, P 7, and tightening screw 93A, P 7, each one a little at a time, drawing back the whole gear case until the teeth of the gears are flush with each other. Be sure that both screws 92A and 93A, P 7, are tight. If the teeth on the gears 45A, P 5, and 46A, P 7, are too far apart, so that there is too much lost motion between them, loosen screw 103A, P 5, and screw 93A, P 7, then push the shutter drive shaft and gear 287A, P 2, and

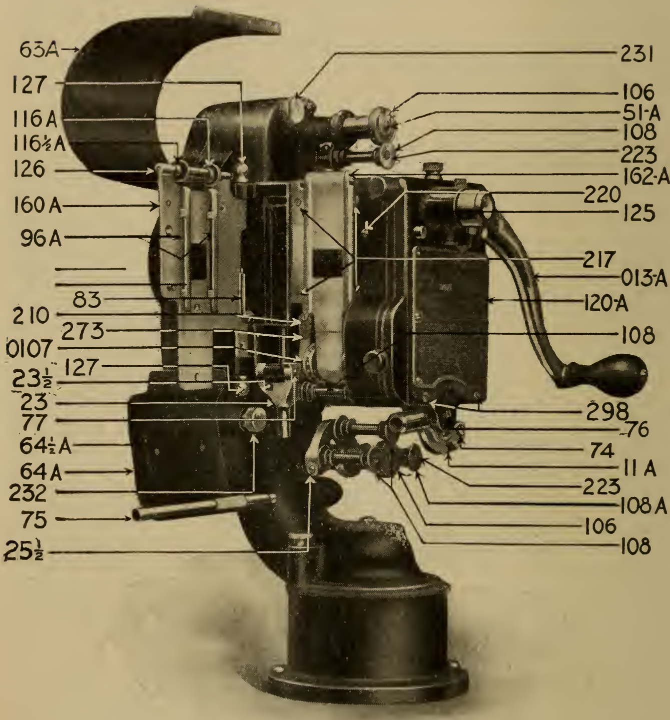


Plate 3
Fig. 110

the shutter gear case 288, P 7, over toward the shutter side of mechanism, both at the same time until the gears are just close enough together so they will not bind, and may be turned freely with the fingers, and so the gears will run flush with each other, then hold them in this position and tighten screws 103A, P 5, and 92A, P 5, and 93A, P 7. Now replace the gears and gear bridge, then replace the shutter wings by following instruction 13 and 28. Set the shutters as per instruction No. 50.

No. 16.—The Bridge, 4A, P 4 and 5, may be removed by (a) loosening screws (three of them) 224, P 4, backing them out about a half inch; (b) gently and evenly prying the bridge off with the point of a screw-driver, or working it outward with the fingers until it comes away from the main frame of mechanism; (c) then turn the screws all the way out of main frame. It is unnecessary to remove them from the bridge, as they are necked in order that they may be left in the bridge to prevent them from becoming lost.

No. 17.—Gear 87½, P 4, is removed by taking out screw 129, P 4, which serves also as its spindle.

No. 18.—Main Gear, 15A, P 4, is removed by (a) removing gear bridge as per instruction No. 16; (b) pulling same from its shaft.

No. 19.—Balance Wheel No. 14, P 4 and 6, may be removed by (a) removing bridge as per instruction No. 6; (b) removing screws 205 (two of them), P 2. Screws 205 are deeply countersunk into the shaft, hence must be removed entirely before balance wheel will be released.

No. 20.—Gear No. 84A, P 2 and 4, and **Governor Drive Shaft** 40A, P 2, may be removed by (a) following instruction No. 16; (b) driving out taper pin 135, P 4.

No. 21.—Any of the Three Bushings in the Bridge may be removed simply by loosening their respective set-screws (three of them) 225, P 2. A new bushing may then be set into place.

No. 22.—Gear Sleeve 62A, P 2, may be removed by (a) following instruction No. 16, P 19, and then removing the screw near the outer end of the sleeve and the one in the center of the sleeve on the latest model 1912 machine, earlier models have but the one near the outer end of the sleeve. The gear sleeve will then slip off the smaller center balance shaft, 61A, P 2.

No. 23.—Balance Wheel Shaft 61A, P 2, may be removed by following instructions No. 22 and then removing the framing carriage as per instruction No. 35. The spindle may then be slipped out into the interior of the machine. The inner bearing

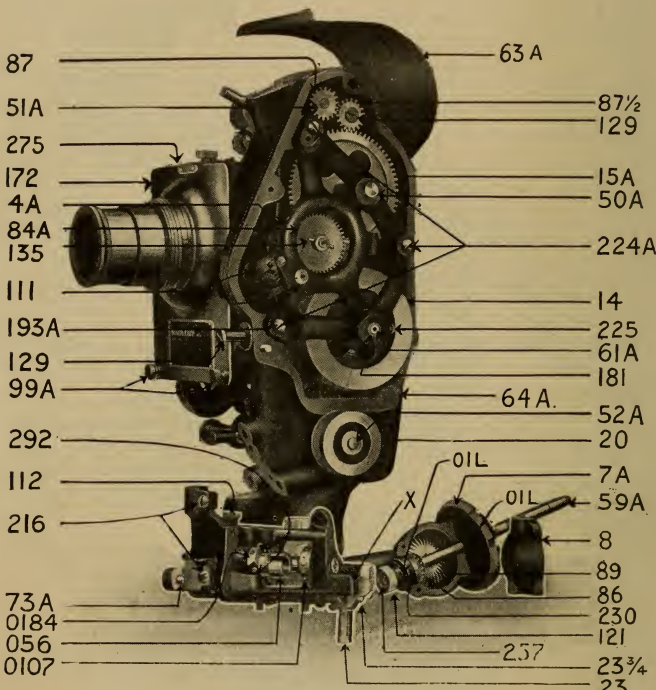


Plate 4

Fig. 111

or bushing which carries this spindle may be removed by loosening screw 276, P 1, drawing it back quite far, as it is deeply countersunk into bushing. Place a strip of hard wood through the opening on right-hand side of mechanism when facing to the front and against the bushing, tap it lightly with a hammer, pushing it out toward the gear side.

No. 24.—Idler Gear 18A, P 2, may be removed by (a) following instruction 16 and 19 (b) removing screw 129, P 2.

No. 25.—Governor Crank Arbor 83A, P 3, and 7, may be removed by following instruction No. 5, 16, 18 and 28, and then loosening screw 200, P 2 and 7, the arbor may then be pulled out through rear of mechanism.

No. 26.—The Automatic Fire Shutter Governor may be removed by proceeding as per instruction No. 25. When the crank arbor is pulled out it also releases the governor.

No. 27.—Adjustment of Governor and Fire Proof Shutter. (a) Remove front plate as per instruction No. 3; (b) loosen screws 225 and 235, P 5, which releases the two bushings 193A, P 4, and 194, P 5. (c) Hold the bushings between the thumb and finger and slide them, together with the governor, slightly toward the gear bridge 4A, P 4. Looking through the front of mechanism, through the aperture opening in aperture plate 162A, P 3, the fire shutter 163, P 1, will now be observed slightly raised. (d) Still holding the bushings between the thumb and finger, slide them together with the governor slowly back toward the shutters until the fire shutter 163, P 1, just barely rests on stud B, P 1. (e) Hold them in this position and tighten screw 235, P 5. (f) Hold bushing 193A, P 4, lightly against the shoulder of the governor shaft 65A, P 2, and tighten screw 225, P 5. There should be very little or no end play of the governor shaft 65A, P 2, when screws 225 and 235, P 5, have been tightened, but be sure that the governor shaft turns freely when the machine is in operation. Otherwise machine will turn hard and will cause unnecessary wear on the gears. If properly adjusted as above, the fire shutter 163, P 1, will readily raise all the way up and rest on stud A, as shown in P 1, when machine is in operation, and will just as readily drop all the way down and rest on stud B, P 1, when machine is stopped. The raising of the automatic fire shutter is accomplished by the spreading apart of the governor balls 111, P 4, when machine is put in motion, pulling the roller guide 110, which is located on the opposite end of governor shaft 65, P 2, from gear 90, P 2, toward them, same being connected with governor crankshaft 19, P 2 and 7, which is fastened to governor crank arbor 83, P 3 and 7, and is connected to

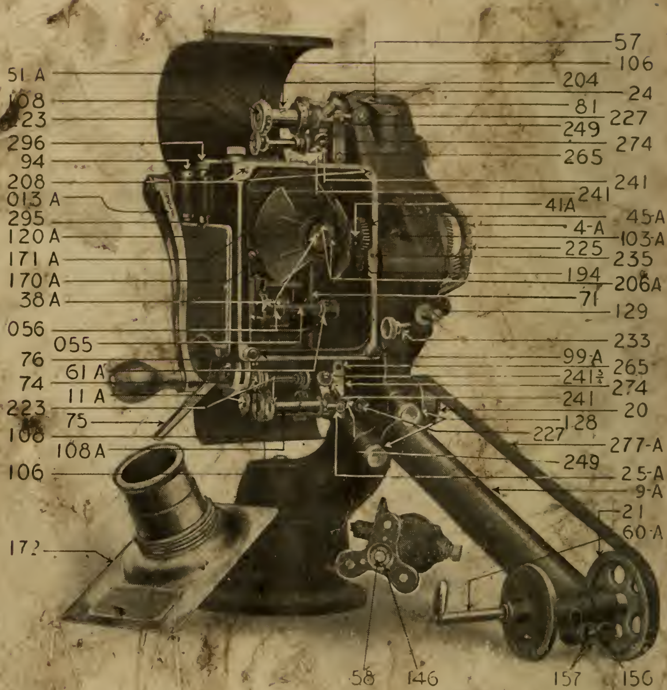


Plate 5
Fig. 112

rack-bar 168, P 1, same being in turn connected with a small gear on fire shutter, 163, P 1, all of which work together automatically. When the machine is stopped, the governor balls are brought together by the governor spring 175, P 6, which again lowers the fire shutter. The fire shutter 163, P 1, and rack-bar 168, P 1, may be removed by first removing gate as per instruction No. 5, then removing the two small flat-head screws on the inside of gate, and the three small round-head screws on the outside of gate, then lay the gate upon a table or upon a base-board with the tension shoes 96A, P 3, down and lift off the heat shield 164A, P 2. The rack-bar 168, P 1, and shutter and gear 163, P 1 may now be lifted off. The shutter and gear are fastened together and are listed as one part, 163. To replace same, be sure that the small pivot on the gear side of shutter enters the hole for same in the main frame of gate. Then place the rack-bar in position, having the shutter raised all the way up, place the first two teeth on end of rack-bar, engaged with the two top teeth on the gear, replace the heat shield, being careful that the pivot on upper side of shutter enters hole for same in heat shield and replace all the screws.

No. 28.—Gear 16A, P 2, is removed by following instruction No. 16, 18 and 19, and then removing screw 129, P 2.

No. 29.—Main Crank Shaft 58, P 4, may be removed by taking off bridge as per instruction 16, and pulling gear 15A from its shaft. Next remove the crank by loosening screw 154, P 1; push rod 94, P 4, down, and pulling outward on the crank. Crank shaft 58, P 4, may then be pulled out from the gear side.

No. 30.—To Remove Bevel Gear 86½, P 2, loosen the set screw in its hub, backing the same out for a considerable distance, as it is deeply countersunk in the shaft. Its spindle 57, P 2, the top end of which is shown at 57, P 5, may then be raised out, which will release the gear. It also releases bevel gear O85, P 2.

No. 31.—Bevel Gear O85, P 2, may be removed by following instructions No. 29 and 30. This releases this gear, which may then be taken out.

No. 32.—Take-Up Belt Pulley 20, P 4, and 5, may be removed by loosening the set-screw in its face.

No. 33.—Guide Roller at Top of Gate, 116A, and 116A, P 3, together with the small spiral spring inside of the hub of 116½A, may be removed by driving out the spindle which holds same. These rollers should be removed if at any time the film wears a flat spot or spots on the surface of their inside hub. This is unlikely to occur, as the rollers are of hardened steel.

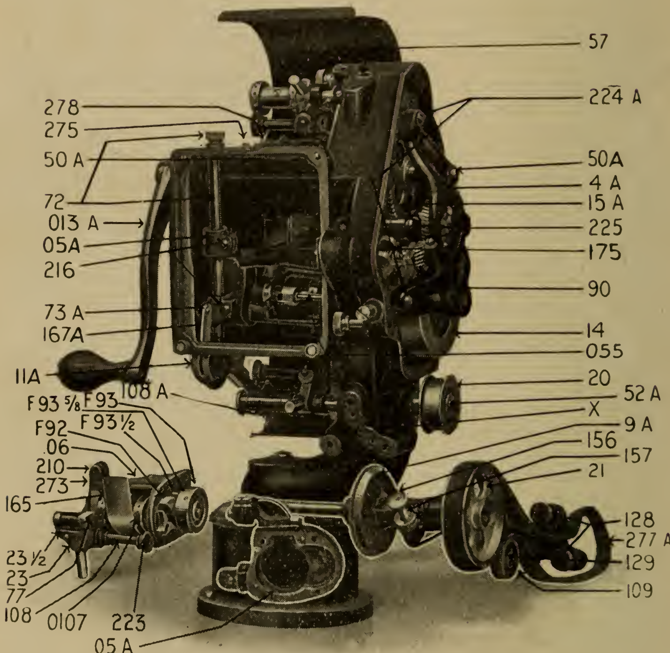


Plate 6

Fig. 113

No. 34.—Latch Pin 296, P. 5, is for the purpose of releasing side plate 120A, P 5. Raise pin 296 up, and side plate No. 120A will be released and can be removed, exposing the side of the framing carriage, thus allowing you to get at oil cup 112, P 1 and 4, in the top of the framing carriage. This oil cup supplies lubrication to the Geneva movement, which runs in the oil-well, shown at O5, P 6, the same being detached from the rest of the carriage, in the latter illustration. The knob of latch pin 296, P 5, may be unscrewed, which allows the pin to drop out from below, revealing a spiral spring on its stem. Hold the bottom of the pin with a pair of pliers while you unscrew the knurled top .

No. 35.—Removing and Replacing the Framing-Carriage. To remove the framing-carriage, proceed as follows: (a) follow instruction No. 34; (b) loosen screws 216, P 6, and remove framing-carriage slide rod 72, P 6, the carriage may then be lifted out through the opening made by removing side plate 120A, P 5. To replace the framing carriage, just reverse the above-described process, being sure however, to enter guide rod 71, P 5, in slot X, P 4, and to get ball arbor O55, P 5 and 6 properly entered in knuckle joint socket O56, P 4, and balance wheel shaft socket 61A, P 5, by taking the small square block between the thumb and finger of the right hand and guiding it into slot of socket. The ball arbor O55, P 5 and 6, is the same at both ends, therefore it does not matter which end goes in O56 or 61A socket. After replacing the carriage, screws 216, P 6, should be tightened up until the framing lever works right; that is to say, until the framing-carriage does not work too hard or too easy. If it works too easy, it is liable to work down of its own accord while machine is in operation, thus causing picture to get out of frame.

No. 36.—Adjusting the Geneva Movement. Intermittent sprocket O107, P 3, should have just a little circumferential play. If set up too tight when machine is cold, there may be a slight binding after the machine warms up, due to expansion of the parts through heat. This play, however, should be very slight, and, when through wear of parts it becomes too great, it may be eliminated as follows: On P 4, we see the framing-carriage lying at the base of the machine and part O184 thereon is the eccentric bushing which carries the shaft to which is affixed cam F93, P 6. Eccentric bushing O184, P 4, is held in position by three screws No. 102, P 1, and 292, P 4. 102, P 1, being the set screw, and the two screws 292, P 4, are the adjusting screws. To eliminate the lost motion in the intermittent sprocket, proceed as follows: (a) after having removed

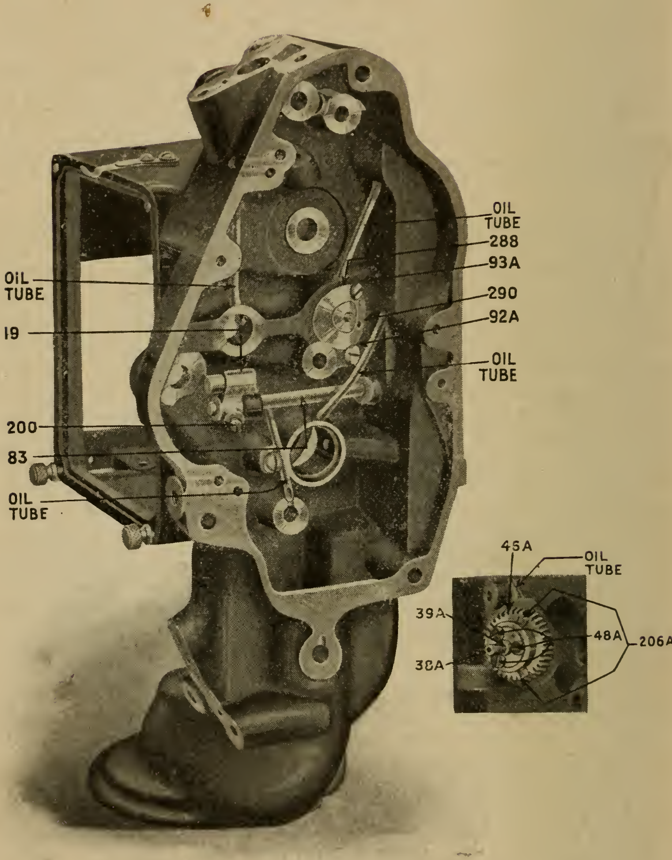


Plate 7
Fig. 114

framing-carriage as per instruction No. 35, loosen screw 102, P 1; (b) loosen the lower adjusting screw 292, P 4, slightly, then tighten the upper adjusting screw 292, P 4; this operation may be repeated, loosening the upper and tightening the lower screw a little at a time until the proper adjustment is obtained. In case it is brought up too tight, simply reverse the above operation by loosening the top screw 292, P 4, and tightening the lower one, 292, P 4. By this method a very much finer adjustment may be obtained than by the old method of simply turning the eccentric bushing. After the proper adjustment is obtained, be sure and retighten set-screw 102, P 1; in fact, have all screws perfectly tight before replacing framing-carriage.

No. 37.—The Star F92 and **Cam** F93, P 6, may be gotten at by removing screws 215 (four of them), P 1, which releases the oil-well cover or vertical part of framing-carriage O5A, P 6.

No. 38.—Note: Directions follow for the removal and renewal of cam, star and intermittent sprocket, and their bushings. I do not, however, advise this; it is much better to purchase an extra framing carriage, and when anything goes wrong with the old one, or when excessive wear develops in the bushings, spindles, intermittent sprocket, or other parts, insert the new carriage in the machine and send the old one to the factory by registered mail for repairs. It is, of course, possible that the operator can and will make the necessary repairs in an entirely satisfactory manner. Still, when one considers the delicacy of the parts, and the fine adjustment necessary, one readily sees that this can be best done at the factory, where all kinds of tools, and the men skilled in this class of work, are available.

No. 39.—Ball Socket O56, P 4, may be removed as follows: (a) follow instructions Nos. 35 and 37, (b) remove screw 293, which holds socket O56, P 4, on cam shaft. In the center of ball socket O56 will be seen the end of the cam shaft. The end of the cam shaft and the shaft opening in the ball socket are slightly tapered; (c) place on the end of the cam shaft a punch of brass or hard wood or of very soft steel will do, tap lightly with a hammer; this will release the socket from the cam shaft. The end of the punch must never be rounded but should be perfectly flat and preferably should have a hole in the center so as not to flatten down the leather cushion. Never, under any circumstances, use a hard steel punch, and be careful that the punch sets square on the shaft. A special three-piece vest-pocket size punch or tool set for this purpose may be obtained from the manufacturers of the Motiograph for $1.00. This punch, in fact, is three punches of three different sizes, with three different size holes and may be stuck together or assembled in one piece and carried in the pocket the same as a pencil. Place the new socket on the end of cam shaft and through the hole for screw 293, which holds socket to the shaft, observe that the hole sets accurately over the countersink in shaft; then with the framing-carriage in an upright position rest the cam on a suitable solid support, and with a piece of hard wood or brass placed on top of the socket, or by use of the vest pocket punch, tap it lightly with a hammer in order to bring it firmly into place; then insert the screw 293 and screw it down very tight; if lightly driven on in this manner into proper position, and the screw firmly tightened, there is no danger of its ever coming loose.

No. 40.—The Cam and Shaft, F93, P 6, may be removed and replaced as follows: (a) follow instruction 39; (b) remove the old cam by pulling the shaft out of eccentric bushing O184, P 6, by taking hold of cam F93, P 4, insert new cam and replace socket as per instruction No. 39.

No. 41.—The Star and Shaft F92, P. 6, may be removed and replaced as follows: (a) follow instructions Nos. 40 and 46; (b) remove screws 43A (two of them) which will be found in the hub of intermittent sprocket O107, P 3, just underneath the apron or stripper plate 165, P 6; then by taking hold of the star wheel F92, P 6, pull it out and insert new one, being careful to get the screw holes in the shaft right side up. *Keep in mind* the fact that steady pictures depend more on the absolute accuracy of the intermittent sprocket and the star and cam than on any other part of the machine, hence it is of the most vital importance that the greatest care should be exercised in order to maintain the accuracy that is absolutely necessary to the production of good work. As the fitting of the cam to its shaft is an operation that cannot be well done without special facilities, the manufacturers have combined these two parts as one and they are so listed in the parts price list, and no operator or mechanic should, without the special facilities, undertake to separate the cam from its shaft and expect to fit another in a way that will do accurate work. The geneva driver pin F93½, P 6, may be removed for replacement by loosening screw No. F93⅝, P 6, which holds it in position. The star and shaft is made in one solid piece and is very accurately ground by high-grade automatic machinery.

No. 42.—The Intermittent Sprocket O107, P 4, may be removed and replaced as follows: Follow instructions Nos. 39, 40 and 41.

The life of the intermittent sprocket on the latest improved 1912 framing device called the Model W, has been increased by a special hardening process perfected by the manufacturers of the Motiograph. In order to use this sprocket on the 1909, 1910 and 1911 models it will be necessary to also purchase the star and shaft or to send in the one which is intended to use with same to the manufacturers in order that the screw holes may be drilled out properly and the sprocket lined up as the hub of said sprocket is slightly larger than formerly and the screws run clear through.

No. 43.—The Eccentric Bushing O184, P 4, may be removed and replaced as follows: (a) follow instruction 39; (b) loosen screws 102, P 1, and 292, Ps 1 and 4 and push bushing out toward sprocket and insert new bushing.

No. 44.—The Large Bushing O28, which will be found just underneath the star, F92, which supports the star shaft may be removed and replaced as follows (a) follow instruction No. 41; (b) loosen screw No. 214, P 1; (c) push bushing out toward the star wheel side, then insert new bushing.

No. 45.—Small Bushing O183, P 4, may be removed and replaced as follows: (a) follow instruction No. 41; (b) loosen screw No. 213, P 1; (c) push bushing out, then insert new bushing.

No. 46.—The Apron or Stripper Plate 165, P 6, is released by removing three screws which hold it at its lower end.

No. 47.—Intermittent Idler Bracket 23, P 6, may be released by removing joint pin 77, P 6. The distance intermittent idler 108, P 6, is held away from the sprocket, is controlled by screw 23½, P 6, which is in turn held in place by set screw 23¾, P 4. It should be set away from sprocket by about twice the thickness of a film.

No. 48.—Governor Shaft Bushing 194, P 5, is held in place by set-screw 235, P 5. By loosening this set-screw, the bushing may be adjusted or removed. Note the oil hole in the face of this bushing and in putting in a new one, or adjusting the old one, be sure to keep it at the top.

No. 49.—Ball Arbor or Shaft, O55, P 5, works at high speed, hence it is quite likely that in the course of time the square blocks and the slot in which they fit may become worn. This will cause considerable noise, and if allowed to become too badly worn may also cause picture to jump, especially when trying to speed up a little. It may be remedied by obtaining a new ball arbor O55, P 5, and if necessary socket for same. The latest style sockets are much larger than formerly, and are hardened. The latest style ball arbor or shaft is made so that the square blocks called trunnions and numbered O55½ may be removed and replaced without replacing the entire ball arbor, providing the ball part is not too badly worn. The right-hand socket 61A, P 5, is a part of flywheel shaft. It may be removed by following instruction No. 23.

No. 50.—Setting the Shutter. Setting the No. 1 intermittent double cone shutters on the No. 1-A Motiograph, model, 1912: The principle of setting the shutters on the Motiograph is the same as any other motion picture machine; that is, the larger wings of the shutters should cover the light opening or aperture, as nearly as possible during the time the intermittent sprocket and film are in motion and the smaller wings should pass during the exposure while the film is at rest. It is not necessary to pay any attention to the small wings when setting the shutters, as they take care of themselves and are only intended as interruptors of the light, which reduces the flicker in the picture to a minimum. To set the shutters, proceed as follows: (a) follow instruction No. 3; (b) remove the outer shutter wing 171A, P 5, by loosening screws 206A, P 5, and pull shutter from its shaft; (c) loosen screws No. 48A, P 7, leaving them just loose enough so the inner shutter 170A, P 5, may be turned by hand, but tight enough so that it will not move of its own accord; (d) remove gear cover as per instruction No. 1; (e) take hold of the balance wheel and turn the mechanism in the same direction as when in operation. Turn very slowly until the intermittent sprocket is just barely ready to start moving, after which set the lower edge of the large wing of the inner shutter 170, P 5, about ⅛" above the center of the aperture opening, when looking on a horizontal line through the center of the aperture. Now revolve the mechanism slowly in the direction it runs, observing when the intermittent sprocket stops that the top edge of the large wing of the inner shutter 170A, P 5, is about ⅛" below the center of the aperture opening; tighten screws firmly, after which revolve the mechanism until the inner shutter is at the original position; that is, the lower edge of the large wing should be about ⅛" above the center of the aperture; replace the outer shutter 171A, P 5, on the shaft; tighten screws 206A, P 5, partially in the same manner as was done with the inner shutter; set the top edge of the large wing about ⅛" below the center of the aperture opening, after which tighten the screws firmly. The space between the two large wings of the shutters should be exactly the same width when the intermittent sprocket is just ready to start (but not started) as it is just as the intermittent sprocket has come to rest after turning, and said space should be exactly in the center of the aperture opening when looking on a line parallel through the aperture opening. After the setting of the shutters has once been done, it will be found very simple and easy to repeat.

No. 51.—Sprocket Idlers 108 (all sprocket idlers have same number) must be set away from their respective sprockets by about twice the thickness of an ordinary film. This, however, does not apply to the front idler of lower bracket (front means the lens side of the machine) which may set as much as ⅛" away from the sprocket. The distance of the idlers from the lower sprocket is governed by screw No. 241¾, P 5, and that of the upper idler is governed by screw 241½, P. 5. After the proper adjustment is obtained, both may be set by means of the lock-nut 241, P 5. All idler rollers are now made of hardened steel.

No. 52.—The Sprocket Teeth. The teeth of the intermittent sprocket O107, P 3, are subject to the heavy wear, due to pulling the film down against the pressure of the tension springs. This has the effect of cutting away the metal on one side of the teeth. It is called "undercutting." If this wear is of considerable extent, it is likely to render the picture unsteady on the screen, as well as to be very hard on the perforations of the film itself. An intermittent sprocket should never be used after its teeth have become worn to any considerable extent. An extra framing-carriage complete should be kept on hand, ready to insert in the machine. This extra carriage will cost you only a few dollars, and it is well worth the money. The teeth of the upper and lower sprockets 106, P 3, and 106, P 3 (upper and lower having the same number), are also subject to considerable wear, particularly those of the lower sprocket. These sprockets cannot be turned end for end when the teeth become worn. But the wear upon the teeth of the upper and lower sprocket is on opposite sides, hence, these two sprockets may be changed, one for the other, when they become worn, thus presenting a new and unworn side of the teeth to the film. The sprocket teeth should be carefully watched. Don't depend on your naked eye, but examine them through a condenser lens which will magnify them and show you more clearly their true condition.

It does not, from any point of view, pay to run a machine with badly worn sprocket teeth. Particularly does this apply to the intermittent and the lower sprockets.

No. 53.—The Face of Sprockets should be kept very clean. Dirt on the face of the intermittent sprocket will cause the picture to jump. Dirt on the face of the upper and lower sprocket has a tendency to cause the loss of the loops. An ordinary tooth brush is the best thing to clean the sprockets. They should be thoroughly cleaned once every day.

No. 54.—Framing Carriage. Should your framing-carriage work too easily and have a tendency to drop, the matter may be remedied by tightening screws 216, P 6. If the framing-carriage works too hard, of course these screws should be loosened slightly.

No. 55.—Lower Reel Arm, 9A, P 5, is attached to the machine by thumb screws 128, P 5, and a third, similar one which does not show in the illustration. Pulley 21, P 6, which drives the take-up reel in the lower magazine, is driven by a flat belt, 227A, Ps 5 and 6, tension to which is supplied by idler pulley 109, P 6. (Note: Oil hole in the face of pulley 109, and don't overlook it in oiling.) The amount of tension which pulley 129, P 6, will supply to belt 227A, P 6, is governed by adjusting screw 156, Ps 4 and 5. After adjusting belt tension, set up lock-nuts 157, Ps 5 and 6, tightly. Only sufficient tension should be given to enable belt to revolve the lower reel, until all the film is taken up. Anything more than this is excessive, and highly undesirable from any and every point of view. Too much tension on the take-up will have a decided tendency to cause losing of the lower loop; also it is very hard on the film, sprocket holes, and makes the machine run unduly hard, also causing unnecessary wear on the lower sprocket. The Motiograph take-up belt may be allowed to run very slack. If it shows a tendency to get hard and stiff, a few drops of oil will soften it.

No. 56.—Take-Up Drive Pulley, 21, P 6, **and Its Shaft,** 68, P 5, **and the Bracket Carrying Idler Pulley,** 109, may be removed by taking out the set-screw in the hub of pulley 109. This releases all the parts. Before taking the pulley off, carefully note the position of the bracket carrying idler pulley 109, P 6; also note the washer between the pulley hub and the idler bracket casting, and don't forget to replace same when the parts are put together again; also note the flat spot in the spindle into which set-screw in hub of pulley should fit. Lower magazine fits over and around casting 9A, P 5, and is held thereto by thumb-screws in the magazine spider casting. *Note:* It will, of course, be understood that the lower reel arm, framing-carriage, etc., shown at the base of the machine in P 6, and the various parts shown at the base of the machine in other plates, are not in their normal position, but merely laid down by the side of the machine for the purpose of illustration. For instance, in P 6, we see one view of the lower-reel arm, and in P 5 we see another view of it. But in the latter view the reel-arm is in place on the machine.

No. 57.—The Rewinder. Rewinding is done on the machine itself, the same being accomplished by shifting the two magazines so that their fire-traps are in line with each other, the film passing directly from the lower to the upper magazine, in front of the mechanism, the upper reel being revolved by the machine crank O13, P 5. The two magazines are both shifted simultaneously, or at the same time, by lifting the stop-bolt in the spider of the upper magazine, the lower magazine being connected to the upper by a shift-bar; turning the upper magazine also turns the lower. In P 2, we see the lower end of upper reel-arm 7A in place on the machine. We also see bevel gear 86½, P 2, which drives socket spindle 57, P 2, top of which is seen at 57, P 6. Socket spindle 57, P 2, in turn, imparts motion to a shaft extending up through the center of reel arm 7A, P 2, the lower end of which is shown at 58, P 5. In P 5 we have a view of the lower end of reel-arm 7A, which lies beside the machine. Pin 146, P 5, fits in the slot in the top of socket shaft 57, Ps 5 and 6. In P 4, we have a view of top reel-arm 7A with gear cap 8A, P 4, removed. This cap is released by removing four screws in its upper surface and carefully prying it off.

No. 58.—The Rewinder Acts as Follows: When machine crank O13, P 5, is clear in, as shown, it drives the mechanism and is not engaged with the rewinder. By shoving down the push-rod 94, P 5, at the same time revolving the crank and pulling outward on it, the crank and crankshaft will be moved outward by about ¼″. In P 2, we see a view of main driving gear 15A, which is shown in its place in the machine on P 4. In the face of its hub, you will see four slots Y, P 2. Looking at bevel gear O85, P 2, you will see four similar slots in its hub. You will also see a pin through the crankshaft in front of gear O85, P 2. The operation is as follows: When the crank is shoved clear in, this pin engages with two of the slots Y, P 2, which locks the crankshaft with gear 15A, P 4, and revolves the mechanism itself. When push-rod 94, P 5, is depressed and the crank revolved while pulling outward on it, the crankshaft and crank slip outward, thus disengaging the pin from the slots in gear 15A, P 4, and engaging it with the slots in gear O85, P 2. This releases the mechanism, which no longer revolves when the crank is turned, and locks the crank to gear O85, P 2, which revolves the rewind. This may seem to be a little complicated, but it is in reality very simple, and will be easily followed through the various illustrations at the same time examining your own machine.

No. 59.—Bevel Gear, 86, P 4, and Shaft 59A, P 4, is removed by (a) loosening set-screw in the hub of the brass gear; (b) removing screw 257, P 4, in end of the shaft.

No. 60,—Bevel Gear, 89, and the Vertical Shaft to Which It Is Attached may be removed by taking out pin 146, P 5, first having removed bevel pin on 86, P 4, as per instruction No. 59.

No. 61.—The Bushing at the Upper End of Vertical Shaft 58, P 5, is held in place by a set-screw just below the bulge in the casting. Note the oil holes on the face of upper reel-arm 7A, and don't overlook them in oiling.

No. 62.—Oil. Many of the machine parts work at high speed and they all have more or less heavy labor to perform. It therefore follows that they should receive adequate lubrication; "adequate lubrication," however, does not mean that the bearings should be flooded with oil. One drop of oil is sufficient on any motion picture mechanism bearing. Anything more than this simply runs off and makes a mess. Use good oil. The use of very thin oil and much advertised patent oil should be avoided. *A good grade of light dynamo oil is best.* This applies to everything except the intermittent movement oil-well, in which a good grade of vaseline or other equally efficient lubricant should be used. If vaseline is used, it may be heated and put in, in the usual way, through oil-cup 112, P 1, or by removing the vertical casing O5, P 6, by following instruction No. 37, and force the vaseline in around the Geneva star and cam.

No. 63.—Keep the Machine Clean. A dirty, oily, smeary mechanism is very good evidence of a careless operator, and the careless operator is usually a poor operator, regardless of how much he may know. It only takes a few moments each day to wipe the machine off clean, and it should by all means be done. It is an excellent scheme to lay a small square of heavy blotting paper inside the mechanism, which can be renewed every day. It will absorb the surplus oil and help to keep things clean.

NAMES AND NUMBERS OF PARTS FOR THE MOTIOGRAPH, No. 1A MODEL, 1912.

Order Parts by Number Only, But Where Number Is Preceded by a Letter, the Letter Is an Integral Part of the Number. In Ordering Parts, Be Sure to Give the Serial Number of Your Machine.

1-A	Main Frame Casting of Mechanism.
2-A	Sub Base for Wood Base Board.
3-A	Gear Cover.
4-A	Gear Bridge.
05-A	Framing Device, Vertical Casting.
06-A	Framing Device, Horizontal Casting.
7-A	Upper reel arm, casting only
8-A	Upper Reel Arm Cap.
9-A	Lower reel arm, casting only
10-A	Take-up Belt Tension Idler Bracket.
11-A	Framing Lever Casting.
12-A	Hand Bolt to Clamp Mechanism to Base.
13-A	Crank Handle, Casting Only.
013-A	Crank Handle Complete.
14	Balance Wheel.
15-A	Main Gear.
16-A	Double Gear Between Main gear and balance shaft gear
17-A	Gear on lower sprocket shaft.
18-A	Gear Between Balance Shaft Gear and Lower Sprocket Shaft Gear.
19	Governor Crank, Complete.
20	Small Belt Pulley and Screw.
21	Large Belt Pulley and Screw.
22	Stereo Lens Mount Ring.
22½	Thumb Screw for Stereo Lens Mount Ring.
23	Intermittent Roller Bracket and Shaft.
23¼	Screw to Bind Roller Shaft in Intermittent Bracket.
23½	Adjusting Screw Intermittent Roller Bracket.
23¾	Screw to Bind 23½ Screw.
24	Roller Bracket, Upper, with Shaft.
24½	Screw to Bind Roller Shaft in Upper Bracket.
25-A	Roller Bracket, Lower, with Shafts.
25¼	Screw to Bind Rear Roller Shaft in Lower Bracket.
25½	Screw to Bind Front Eccentric Roller Shaft in Lower Bracket.
26½	Spring for Magazine Latch.
028	Bushing, Large, for Intermittent Shaft.
29	Magazine Latch, Large Piece.
30	Magazine Latch, Small Piece.
31-32	Magazine Hinge.
33-A	Fire Trap, Casting Only.
33-CT	Fire Trap Complete, with Rollers.
F-33½	Spider Casting Only, for Upper Magazine.
F-33¾	Spider Casting Only, for Lower Magazine.
37	Stereo Lens Arm Bracket.
38 A	Shutter shaft and gear, solid.
39-A	Shutter Shaft and Gear, Main, Hollow.
40-A	Governor Drive Shaft.
41-A	Shutter Drive Shaft Screw.
F-41	Shift bar between magazines.
F-42	Plunger Pin, Upper Spider.
42-A	Bushing for Governor Drive Shaft.
43-A	Screws for Intermittent Sprocket.
44-A	Screw for Gear on Upper Sprocket Shaft.
45-A	Bevel Gear on Shutter Drive Shaft.
46-A	Bevel Gear on Shutter Shaft.
47-A	Intermediate Gears in Shutter Gear Case.
48-A	Screws for Clamping Inner Shutter Wing on Gear Hub.
50-A	Crank Shaft with Pin.
51-A	Upper Sprocket Shaft.
F-51	Spring for Plunger Pin, Upper Spider.
52-A	Lower Sprocket Shaft.
055	Ball Shaft, Hardened.
055½	Trunnion for New Style, Hardened 055.
056	Socket on Geneva Cam Shaft. Hardened.
57	Reel Arm Socket Shaft.
58	Vertical Shaft Inside Upper Reel Arm.
59-A	Upper Reel Shaft.
60-A	Lower Reel Shaft.
61-A	Balance Shaft and Hardened Socket, One Piece, Including Spring Plunger.
61½-A	Spring plunger for new 61-A
62-A	Gear and Sleeve on Balance Wheel Shaft.
63-A	Upper Fire Shield.
64-A	Lower " "
65	Governor Shaft.
65-G.C.	Governor Complete.
69-A	Bushing for Shutter Drive Shaft.
71	Framing Device, Guide Rod.
72	Framing Device Slide Rod, Long, with Head.

73-A Pin Connecting Link, Framing Device.
74 Framing Lever Connecting Screw.
75 Framing Lever Handle.
76 Screw to Hold Framing Lever in Frame.
77 Intermittent Roller Bracket Joint Pin.
80-A Bushing for Shutter Gear Case (Rear).
81 Shaft for Roller Brackets.
83 Governor Crank Shaft.
84-A Gear on Governor Drive Shaft.
085 Bevel Gear on Crank Shaft.
86 Bevel gear on upper reel shaft
86½ Bevel Gear on Rewind Socket Shaft.
87 Gear on upper sprocket shaft.
87½ Intermediate Gear, Small.
89 Bevel Gear on Vertical Shaft in Upper Reel Arm.
90 Gear on governor shaft and hub
91 Stereopticon Slide Rod to Hold Lens Ring.
91½-M Wing Nut and Washer for No. 91.
92-A Screw to Locate Shutter Gear Case.
F-92 Geneva Star and Shaft in One Piece, 1912.
93-A Screw to Retain Shutter Gear Case in Frame.
F-93 Geneva Cam and Shaft Complete for 1912.
F-93½ Geneva Cam Pin. Hardened.
F-93⅝ Screw to Hold Pin in Cam.
94 Push Rod for Rewind Shift of Crank.
95 Locking Pin for Rewind Shift.
96-A Film Tension Shoes.
97-A Round Aperture Heat Arrester on Film Gate.
99-A Thumb screw, front plate (2)
102 Screw to Clamp Eccentric Bushing in Framer.
103-A Screw to Clamp Shutter Drive Bushing.
105-A Cap for Hole, when Changing Over, '09 Screw for Clamping Mechanism to Base.
106 Sprocket, Upper or Lower.
0107 Sprocket, Intermittent on Framing Device.
108 Idler Rolls, Hardened Steel.
108-A Idler Film Roll, Hardened, Lower Roller Bracket.
109 Tension Pulley for Take-up Belt.
110 Roller Guide on Governor Shaft.
111 Governor Balls, Brass (two).
112 Oil Cup on Framing Device.
114-A Shutter Gear Casing Complete with Gears.
116 Roller, Complete, for Top of Gate with Shaft and Spring.
116-A Roller, Top of Gate, Solid End, Hardened.
116½-A Roller, Top of Gate, Spring End Hardened.
118-A Spring for Plunger, to Locate Mechanism on Base.
119 Center pin in magazine hinge
120-A Side Plate to Hold License Plate.
121 Nut, Upper Reel Shaft.
123 Collar on Gate Latch Rod.
F-124 Screws to Connect Shift Bar to Magazine Spiders.
125 Gate Latch Rod.
126 Shaft for No. 116.
127 Ball Screw for Gate Hinge.
128 Screws to Fasten Upper or Lower Reel Arm to Frame.
129 Shaft Screw, Hardened, for Gear or for Belt Tension pulley or stereo lens bracket
133 Pin in Governor Shaft.
135 Pin for Governor Drive Gear.
146 Pin in Vertical Shaft in Upper Reel Arm.
148 Pin in Gear on Governor Shaft.
154 Screw to Fasten Crank to Shaft.
155 Screw to Hold Wood Handle on Stud.
156 Adjusting Screw for Take-up Belt Tension Pulley.
157 Lock Nut for Screw No. 156.
158 Pin in Gear on Shaft Inside Upper Reel Arm.
160-A Main Frame of Film Gate.
162-A Aperture Plate.
163 Automatic Fire Shutter and Gear.
164-A Heat Shield on Gate.
165 Apron or Stripper Plate on Framing Device.
167-A Link to Connect Framing Device with No. 11-A.
168 Rack Bar for Fire Shutter.
169 Governor Strips.
170-A Shutter Wing (Inner).
171-A Shutter Wing (Outer) with Collet and Screws.
172 Front Plate.
F-173 Stud in crank for wood handle
174-A Film Tension Spring to Hold No. 96-A.
175 Governor Spring.
176 Collar on Vertical Shaft Inside Upper Reel Arm.
178 Large Bushing, Bronze, on Vertical Shaft in Upper Reel Arm.
181 Small Bushing in Gear Bridge for Balance Wheel Shaft.
182-A Large Bushing in Main Frame for Balance Wheel Shaft.
183 Small Bushing for Intermittent Sprocket Shaft.
0184 Eccentric Bushing for Framing Device.

193-A Bushing in Bridge for Governor Shaft.
194 Bushing in Frame for Governor Shaft.
198 Small Bushings in Reel Arm.
200 Screw in Governor Crank.
202 Locating Screw for Idler Bracket Spring.
204 Screw for Sprockets, Upper or Lower.
205 Screw for Balance Wheel.
206-A Screw for shutter wing collet.
207 Screw for upper reel arm cap.
208 Locating Screw for Front Plate.
209 Screw to Fasten Magazines to Spiders.
210 Screw for Springs on Framing Device.
211 Screw for Fastening Apron or Stripper Plate on Framer.
212 Screw to Fasten Heat Shield to Gate.
213 Screw to Clamp Small Bushing, in Framing Device.
214 Screw to Clamp Large Bushing, in Framing Device.
215 Screw to Hold No. 05 Vertical Casting to No. 06 Horizontal Casting of Framing Device.
216 Screw to Hold Framing Device in position on slide rod.
217 Screw for Aperture Plate.
218 Screw for Lower Fire Shield.
219 Screw for Studs on Gate.
220 Screw for Gate Latch.
221 Screw for Film Tension Spring.
222 Screw to hold round aperture heat arrester to No. 164-A.
223 Screw to Hold Idler Roller on Shafts.
224-A Screw to Hold Bridge on Main Frame.
225 Screw to Hold Bushings in Bridge.
227 Locating Screw, for Roller Brackets.
230 Screw in reel shaft, bevel gear
231 Screw for Gear Cover, Upper.
232 Screw for Gear Cover, Rear.
233 Screw for Gear Cover, Front.
235 Screw to Clamp Governor Bushing in Frame.
237-M Screw for Attaching Magazine to Reel Arm.
238-A Magazine Body and Cover.
241 Lock Nut on Roller Bracket Adjusting Screw.
241½ Adjusting Screw, Upper Roller Bracket.
241¾ Adjusting Screw, Lower Roller Bracket.
244 Screw for locating crank handle.
245 Set Screw in Gear on Rewind Socket Shaft in Frame.
248 Safety Cap for Crank Shaft, Wood.
249 Screw to Hold Roller Bracket in Place.
251-A Roller for Magazine Fire Trap.
253-A Shaft for Roll in Magazine Fire Trap.
255 Screw to hold traps to magazines.
257 Screw for Nut on Reel Shaft.
258½ Spring for Gate Latch Rod.
259 Set Screw to Bind Bushing in Reel Arm.
261 Wood Handle for Crank.
262 Screw in Framing Device Casting Guide Rod Slot.
263 Screw for Small Belt Pulley.
265 Screw for Roller Bracket Springs.
268 Screw in Magazine Latch.
273 Springs for Intermittent Roller Bracket (2 Pieces).
274 Spring for Upper and Lower Roller Bracket (3 Pieces).
275 Spring to Hold Front Plate (2 Pieces).
276 Set Screw to Fasten Large Balance Shaft Bushing in Main Frame.
277-A Take-up Belt.
278 Screw for No. 275 Springs, Front Plate.
283 Plunger to Locate Mechanism on Base.
283½ Locating Plunger Head.
284 Spring for Push Rod, Rewind Shift.
285 Balance Shaft Screws.
286 Motor Drive Arbor.
287-A Shutter Drive Shaft and Gear.
288 Shutter Gear Case.
289 Screws to Clamp Bushing in Shutter Gear Case.
290 Shaft for Intermediate Gears in Shutter Gear Case.
291 Screw in Gear on Lower Sprocket Shaft.
292 Adjusting Screw for Eccentric Bushing in Framing Device.
293 Screw for Socket on Geneva Drive Shaft.
294 Screw for Upper Fire Shield.
294½ Screw for Heat Arrester Gate.
295 Latch Pin for Side Plate.
296 Nut for Latch Pin.
297 Spring for Latch Pin.
298 Screw for Side Plate.
299 Bushing for Shutter Gear Case (Front).

Power's Cameragraph

INSTRUCTIONS* FOR THE No. 6 MACHINE.

NO 1.—**Lower, or Take-Up Sprocket**, 646, P 2, is removed by loosening screw 738, P 2.

No. 2.—Lower or Take-Up Sprocket Shaft, 645, P 3, is removed by following instruction No. 1, and then pulling the shaft, which carries belt pulley 644, P 2, and pinion 643, P 2, out to the left.

No. 3.—Large Idler Gear, 640, P 4, is removed by following instructions 1 and 2, and loosening set-screw in collar, 642, P 5. Gear 640, P 4, and its shaft, 641 P 5, may then be pulled out.

No. 4.—To Remove Oil Casing Cover, 674, P 4, follow instructions Nos. 1, 2 and 3, after which remove the three screws, 749, P 4, holding the cover, 674, P 4. Tap lightly on the cover to break the shellac in the joint, and the cover will come off. Before replacing the cover, clean its edges, removing all oil, also the edges of the casing itself, and coat the same with thick shellac, which may be had from any dealer in paint supplies. Place the cover quickly in position and clamp it down tightly with the screws. Do not put oil in the casing until the shellac has had time to dry.

No. 5.—Removing the Flywheel. To remove flywheel, 672, P 3, loosen screw 709, P 3, and back it out ⅛ of an inch, then tap lightly on the head of the screw with the handle of the screwdriver, in order to start the wheel from the shaft. Keep backing screw, 709 out and tapping until the wheel can be pulled off. Between pinion 677, P 1 and 7, which is attached to the flywheel and the hub, is the thin washer, 748, P 7. Be careful not to lose this washer and in replacing same, be sure that it goes over pinion engaging pins 747, P 7, and fits up snugly against the hub. In replacing the flywheel, notice the two insets 746, P 7, in flywheel pinion, 677, P 1 and 7, and be sure that pinion engaging pins, 747, P 7, fits into them before tightening up screw 709, P 3. Screw 709, P 3, should be set up quite tight. It will be well for the operator to grind off the end of an old file to use as a screw-driver for screw 709.

*See page 420 for Key.

No. 6.—Removing Cam Shaft. To remove cam shaft, 676, P 2 and 7, follow instructions Nos. 1, 2, 3, 4 and 5. The spindle may then be slipped out to the left.

No. 7.—To Remove Intermittent Sprocket Shaft, 665, P 1, carrying intermittent sprocket 667, P 2, and the geneva cross, follow instructions Nos. 1, 2, 3, and 4. Remove apron 669, P 1 and 2, taking out the two screws (the part number of which is 450), holding same. Loosen screw 743, P 1, and the intermittent sprocket, 667, P 2, and its shaft, and the geneva cross and left-hand (large) bushing may be pulled out to the left. Should it start hard, you may tap lightly on the right-hand end of intermittent sprocket shaft, 665, P 7, using a hard wood, brass or copper punch only. In replacing this part, set the large bushing in its hole in such position that the two small holes, which you will see on its circumference, near the end next the sprocket, will point approximately downward, and then, after replacing the cam and engaging the geneva cross with it, adjust the bushing so that there is just a little circumferential play in intermittent sprocket, 667, P 2; set up screw 743, P 1, tightly when done. The rest of the process of re-assembling is but a reversal of the instructions for taking apart.

No. 8.—Aperture Plate, 687, P 2, is removed by taking out screws (4 of them) 713, P 2. In replacing, be sure and set the aperture so that its lower extension is central between the two flanges of intermittent sprocket, 667, P 2.

No. 9.—Intermittent Roller Bracket, 659, P 2, is removed by taking out screw 715, P. 1.

No. 10.—Intermittent Sprocket Idler Roller, 660, P 2, may be taken from its bracket by removing intermittent roller bracket spindle, 661, P 2, which has a screwdriver slot in its end for the purpose.

No. 11.—Upper Sprocket Roller Bracket, 612, P 2, is removed by taking out screw, 720, P 2. Upper sprocket idler, 609, P 2, may be removed by taking out its spindle, 610, P 2, which has a screw-driver slot in its end for the purpose.

No. 12.—Lower or Take-up Roller Bracket. On later models of the No. 6 machine, take-up bracket roller carrier, 654 P 3 and 7, has been eliminated. The take-up roller bracket is now designed to carry only one roller, the same being mounted directly upon the bracket.

No. 13.—Take-up Roller Bracket Spring, 658, P 2 and 7, is held in place by two screws, 717, P 1, the removal of which releases the spring.

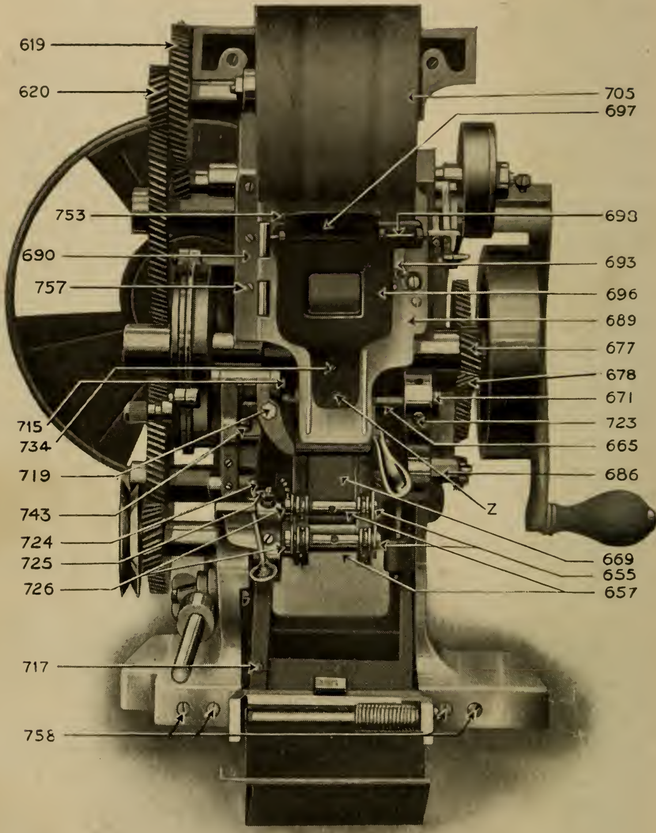


Plate 1.

Fig. 115.

No. 14.—Crank, 632, P 3 and 5, is removed by loosening screw, 751, P 3.

No. 15.—Crank Shaft, 631, P 3 and 5, is removed by following instructions, No. 14, and then driving out the taper pin, 735, P 6, which passes through the shaft, and engages with the slots in the crank hub. This allows you to pull out the shaft, which carries main driving gear, 630, P 4.

No. 16.—Upper Sprocket, 617, P 2, is removed by loosening screw, 738, P 2, which releases the sprocket.

No. 17.—Upper Sprocket Spindle, 618, P 2 and 3, carrying gears, 619 and 620, P 4, is removed by following instructions 14, 15 and 16. The shaft may then be pulled out to the left.

No. 18.—Driving Gear Spindle, 681, P 3, may be removed by following instructions, Nos. 1, 2, 3, 14 and 15. Next drive out the taper pin in hub of gear 680, P 3. The shaft may then be pulled out to the left.

No. 19.—To Remove Revolving Shutter Bracket, 637, P 4, follow instructions, Nos. 1, 2, 3, 14, 15 and 18.

Loosen screw 732, P 4 and 5, and the bracket, carrying shutter shaft, 636, P 4, may then be slipped off.

No. 20.—To Remove Framing Lever, 650, P 4, and its connections, including framing device lever socket link, 649, P 4, and framing device lever socket, 648, P 4, and framing device clamp, 647, P 4; follow instructions Nos. 1 and 2. Take off wingnut, 652, P 5, and remove its bolt by backing it out with a screwdriver; 651, P 3, is the head of this bolt. Remove screws 730, P 4, and the whole thing will come away.

No. 21.—See to it that Studs 686, P 3 and 7, do not work loose. Should these studs, or the slots in horizontal bar 683, P 3 and 7, become so much worn that there is play between studs and slots, do not attempt to close up the slots with a hammer. The bar is die-cast, and you will merely succeed in breaking it. Order a new bar or studs, or both if necessary.

No. 22.—See to it that Screws 728 and 745, P 7, are kept set up tight. If these screws work loose it allows toggle gear 678, P 1 and 7, which fits on 742, P 7, to wobble. This is injurious and very likely to cause a bad grind in the gears, as well as other troubles.

No. 23.—Adjustment for Connecting Link. Connecting link, 682, P 3 and 7, is beveled on its sides. It is held on its right side by a small loose casting, 685, P 3 and 7. This casting is held by screws, 745, P 7. Set screws (two of them), 744, P 7, are for the purpose of holding casting 685, against connecting link,

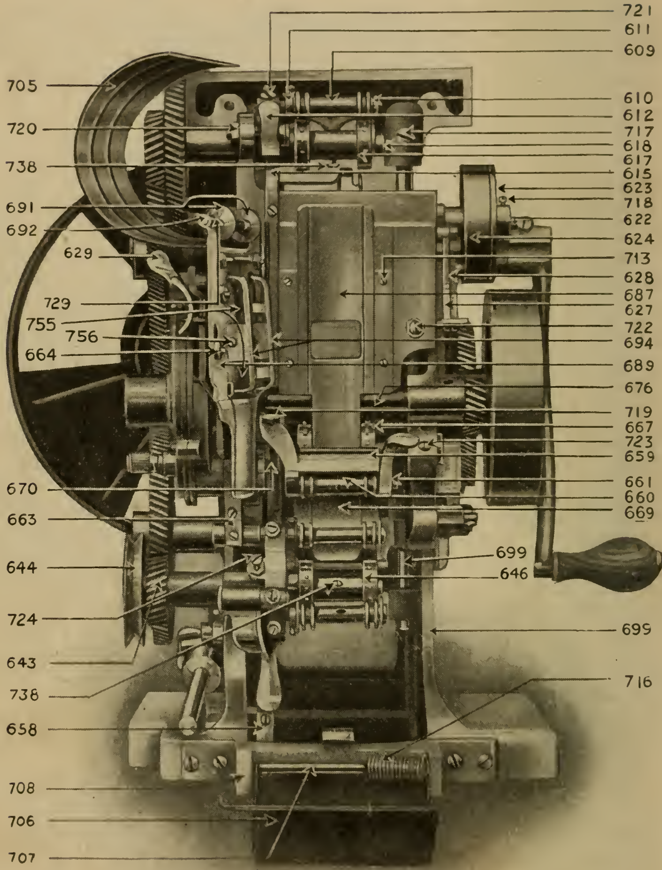


Plate 2.

Fig. 116.

682, to prevent any side motion of same, while at the same time allowing it to slide freely up and down in framing the picture. When connecting link 682, P 3 and 7, develops lost motion, through wear, or from any other cause, first see to it that screws, 745, P 7, are set up tight. If there is lost motion when these screws are tight, loosen screws, 745, P 7, a little and tighten up just a little on set screws, 744, P 7, first having slacked off on the lock-nuts, holding same. Do not set up the set screws too tight or connecting link 682 will bind, making the framing carriage work hard, or possibly stick fast. Tighten screws, 745, and lock-nuts on set screws, 744, when done.

No. 24.—Connecting Link, 682, P 3 and 7, and casting, 685, P 7, are held by guide casting 684, P 7. This casting is attached to the frame by means of two screws, and two small dowel pins. Should it by any chance work loose, it may be re-tightened by removing connecting link, 682, P 7, and small casting, 685, P 7, which will reveal the screw heads. Should the machine grind after re-tightening guide casting, 684, it may be caused by the fact that the casting is too far to one side or the other. If toggle gear, 678, P 1 and 7, seems to be tight against flywheel pinion, 677, P 1 and 7, and loose against gear, 680, P 3, place a small piece of hardwood, or a brass punch against the back (lamphouse) side of casting, 684, and tap it sharply with a hammer to set it over. If toggle gear is tight against gear 680, P 3, and loose against flywheel pinion (when framing carriage is in center of its travel), then tap casting, 684, the other way. This may not help matters, but it at least can do no harm. Instead of the two dowel pins, late machines have a rib and slot to hold casting 684 square.

No. 25.—Upper Film Shield, 705, P 1 and 3, is removed by taking out the two screws, 753, P 1, holding same.

No. 26.—Upper Gate Idler, 691, P 2, is composed of two end flanges and a center spacing roller. The right hand flange is held over against the bushing by spiral spring, 729, P 2, and the whole thing is held in place by spindle, 692, P 2. The various parts, comprising the whole, may be removed by driving out spindle, 692, P 2. This guide roller is for the purpose of holding the film central over the aperture plate, and preventing side motion in the film. See general instruction, No. 6. Should the flanges of this roller hug the film too tightly, it, the film, will have a tendency to climb out from between the rollers and ride on one of the flanges. The remedy is to install a longer spacing roller between the flanges. The trouble may also be remedied by cutting off a small piece of spiral spring, 729, P 2, or

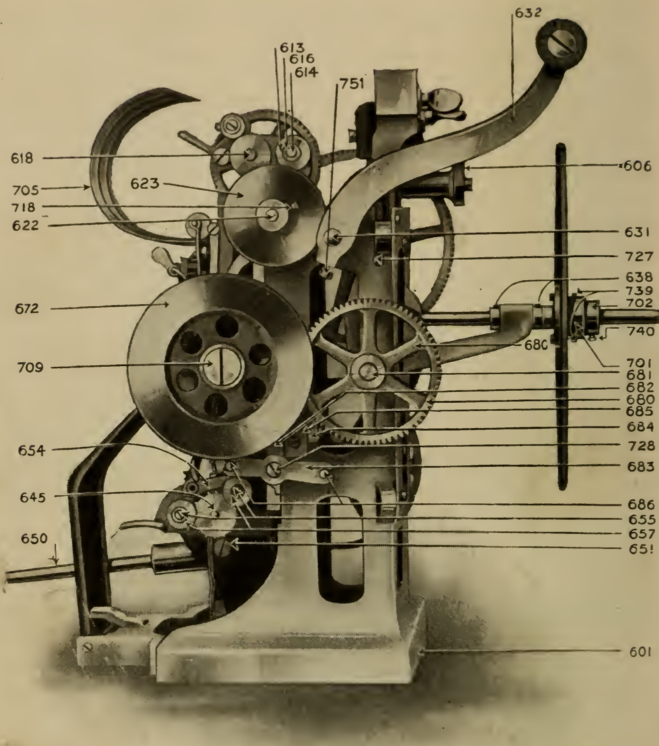


Plate 3.
Fig. 117.

else compressing the spring so that it is shorter. If the central bushing is too long so that the flanges are spaced too far apart, thus allowing side motion in the film, the matter may be remedied by driving out spindle, 692, P 2, and filing a little off of one end of the central bushing. By central bushing, I mean the long hollow roller which holds the two end flanges apart. If spring, 729, P 2, is too weak or short, and does not hold the flanges against the spacing roller, it may be stretched.

No. 27.—Automatic Fire Shutter Flap, 697, P 1, may be removed by taking out pin which holds it to the spindle, and pulling spindle out to the right. It is very necessary that this pin be in place, even though shutter flap, 697, P 1, is tight on the spindle, since the long end of the pin prevents the flap from raising too high, which might cause it to stick, or at least fail to fall promptly.

No. 28.—Counter-Weight, 629, P 2, should be kept set about as shown in the illustration.

No. 29.—Automatic Fire Shutter Governor Arms, 627 and 628, P 2 and 7, must work perfectly free. Otherwise the shutter flap, 697, P 1, is likely not to drop promptly, or else not to raise as it should when the machine comes up to speed. Should these arms have a tendency to bind, loosen screw, 752, P 7, which holds the top of link 628, P 7, slightly. If this does not remedy the matter, then probably the link, or arm have been slightly bent. A little cautious experimenting with a pair of pliers will doubtless fix matters all right. However, before doing this be sure that friction case cover 623, P 2 and 7, works perfectly free on its shaft, when the machine is standing still, of course. Be very careful with the pliers for the parts are die cast and will break easily.

No. 30.—Automatic Shutter Governor Friction Case Cover, 623, P 2 and 7, may be removed by loosening screw 718, P 2. This screw must be backed out considerably, as it is countersunk into the shaft. If the cover does not come off readily after removing the screw, you may drive out spindle 622, P 2 and 3, first having set gear 630, P 4, in such position that gear 621, P 4, will not strike its spokes as the shaft is driven out. Note: In later types of the machine, the rim of gear, 630, P 4, is made so heavy that gear 621, P 4, will not pass it, hence before attempting to drive out shaft 622, P 2 and 3, it will be necessary to follow instructions Nos. 14 and 15.

The removal of shaft 622, P 2 and 3, releases friction case cover 623, P 2 and 7, and friction case 624, P 2. The re-assembling of these parts is merely a reversal of the process of taking them off; but be sure and get screw, 718, P 2, in the countersink in the shaft.

No. 31.—Cooling Plate, 696, P 1, may be removed by taking out screws, 755, P 2. In replacing same see to it that the short, flat spring attached to cooling plate rests against edge of gate latch, 693, P 1.

No. 32.—Tension Shoe, 694, P 2, may be removed by following instruction No. 31, and then loosening screws 756, P 2.

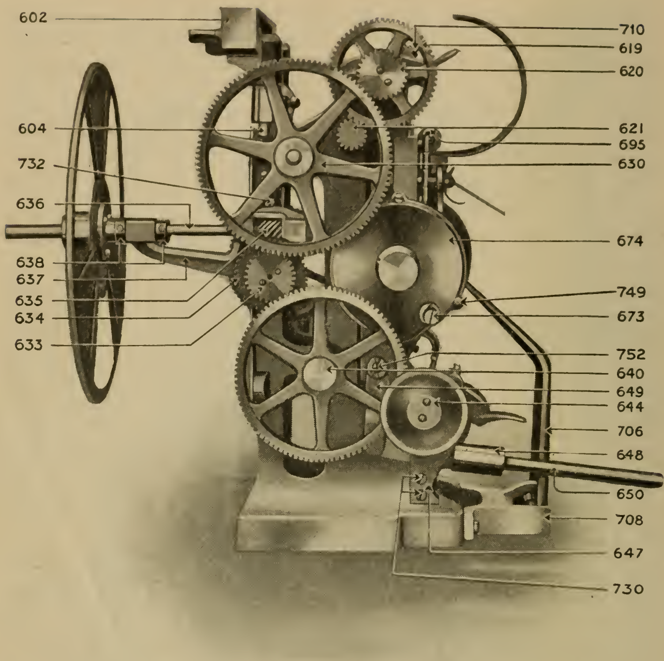


Plate 4.
Fig. 118.

This releases the shoe. The tension is supplied to this shoe by two flat, bowed springs on the back of cooling plate, 696, P 1. The lower ends of these springs rest on a brass clip, the bottom of which is at Z, P 1, which may be forced inward by tension regulating screw 734, P 1. This clip is for the double purpose of supplying greater or less pressure to the bowed tension springs and, through them, to shoe 694, P 2. It also serves to equalize the pressure so that each side of the tension shoe 694, P 2, will bear with equal pressure on the film.

In replacing cooling plate on the gate, be sure that the little short, flat spring rests against gate latch, 693, P 1, since otherwise the latch will not operate properly. See instruction No. 31.

No. 33.—Gate, 689, P 1, may be removed by taking out screws 757, P 1, which releases gate hinge 690, P 1. In replacing same, be sure that the opening in cooling plate 696, P 1, is properly placed in relation to the aperture in aperture plate, 687, P 2. Gate may also be removed by pulling out gate hinge pin 695, P 4.

No. 34.—Lower Fire Shield, 706, P 2 and 4, may be removed by (a) Taking out screws 758, P 1, which hold bracket, 708, P 2 and 4. (b) By driving out spindle, 707, P 2. This latter method releases spring 716, P 2, which is rather difficult to get in again, therefore spindle 707, P 2, should not be removed, unless something is wrong with the spring.

No. 35.—The Entire Framing Carriage, 603, P 7, may be removed by following instructions Nos. 5, 8 and 33. Remove screw, 651, P 4. Next remove front plate 688, P 5 and 6, by taking out screws 754, P 5, and, looking in front (lens side), of the machine, you will see two screws in the upper lugs of the casting which hold the two upright rods, which pass through the framing carriage, and upon which the latter slides. Remove these two screws and pull the two rods out from below, using a pair of gas pliers and twisting the rods as you pull. Having done these various things, you may lift the entire framing carriage out of the machine. CAUTION: On one or both of the rods on the top of the carriage will be seen a small brass washer; also there will probably be one below the carriage. These washers are for the purpose of preventing the carriage from framing too far. They must be replaced in re-assembling the parts and the top washer must be kept at the top and the bottom one at the bottom, since they are likely to be of different widths.

No. 36.—Revolving Shutter Spindle, 636, P 4, may be removed by following instructions Nos. 1, 2, 3, 14, 15, 18 and 19. We may then drive out the pin in gear, 635, P 4, and loosen the screws in collars, 638, P 4. The spindle may then be pulled out.

I would not advise the operator to attempt such a job as this, though it is possible for him to do it. Still, however, it is a job which can best be done at the factory, or at least by a very competent machinist. In far-off countries, however, it will be necessary that these various things be done locally, and for this reason the direction is given. It would be no difficult task for any really competent machinist to do this job, but the average operator would be very likely to find that after he got the gears together again, particularly if he put in new gears, they would be likely to grind more or less, or if he put in a new spindle it might not work freely in the bracket. For these reasons I cannot advise the operator to undertake to put in a new bracket, spindle, or gear, if the machine can be sent to the factory.

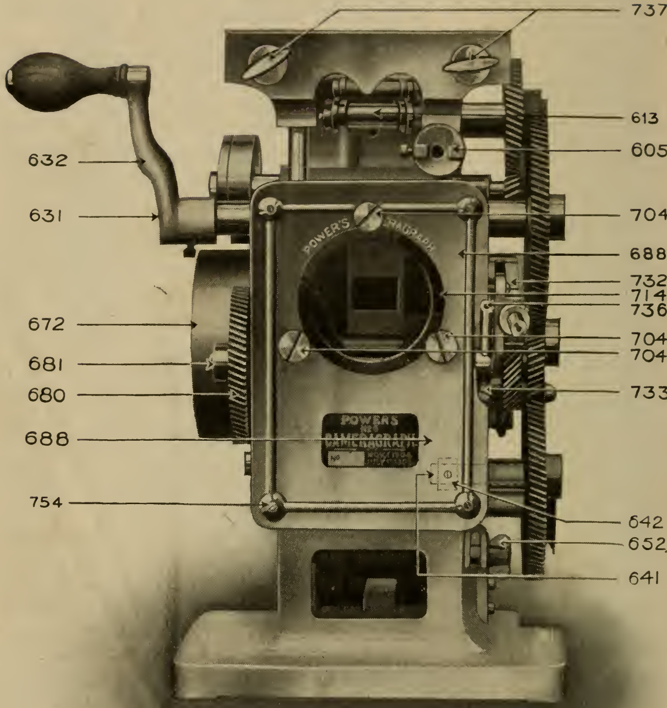


Plate 5.

Fig. 119.

No. 37.—Aligning Sprockets. It is of the utmost importance that upper sprocket, 617, P 2, intermittent sprocket, 667, P 2, sprocket, 646, P 2, and the aperture be kept perfectly and exactly in line with each other. See general instruction No. 4.

No. 38.—Aligning Intermittent Shaft With Cam Shaft. See general instruction No. 12. With Power's No. 6 machine the two shafts are of equal diameter throughout their length and their alignment may be readily tested with a pair of calipers, either taking the distance between the two shafts at opposite ends of the intermittent sprocket, or the distance between the top of the two rims of the intermittent sprocket and the cam shaft. Either method will be effective.

No. 39.—Adjusting Intermittent Movement to Eliminate Lost Motion. The intermittent sprocket should have a little circumferential play, though not very much. As this play increases through wear of the parts, it should be taken up. To accomplish this, loosen screws, 743, P 1, and 723, P 1, and slightly turn intermittent sprocket shaft bushing, 670, P 2, and 671, P 1, in such manner that they revolve clockwise as viewed from the fly-wheel side of the machine. In the end of bushing, 671, P 1, will be found a screwdriver slot, by means of which the bushing may be turned, after loosening screw, 743, P 1. On the circumference of the other bushing (670, P 2), on the end nearest the sprocket, will be found two small holes. By inserting a steel punch, or other suitable instrument, in one of these holes, the bushing may be revolved, after loosening screw 743, P 1, thus tightening the cross against the cam. Insert the punch in the hole in bushing and raise it upward, running the machine slowly meanwhile. If the geneva begins to hammer or the machine begins to bind, you have it too tight and must slack off just a little. In making this adjustment, be sure to keep the sprocket shaft and cam shaft in exact alignment by turning both bushings exactly the same amount. See instruction No. 38.

No. 40.—Extra Part. I would strongly advise purchasers of Power's No. 6 machine to procure an extra framing carriage, with all its parts assembled, so that when the geneva, cam, bushings, or intermittent sprocket become worn, the whole carriage may be taken out and shipped to the factory for repairs, the new one being installed in its place. It will, in the long run, pay to do this.

No. 41.—Intermittent Sprocket, 667, P 2, is attached to its shaft by means of two taper pins. To remove the old sprocket, follow instructions, Nos. 1, 2, 3, 4, 5 and 7. Having thus re-

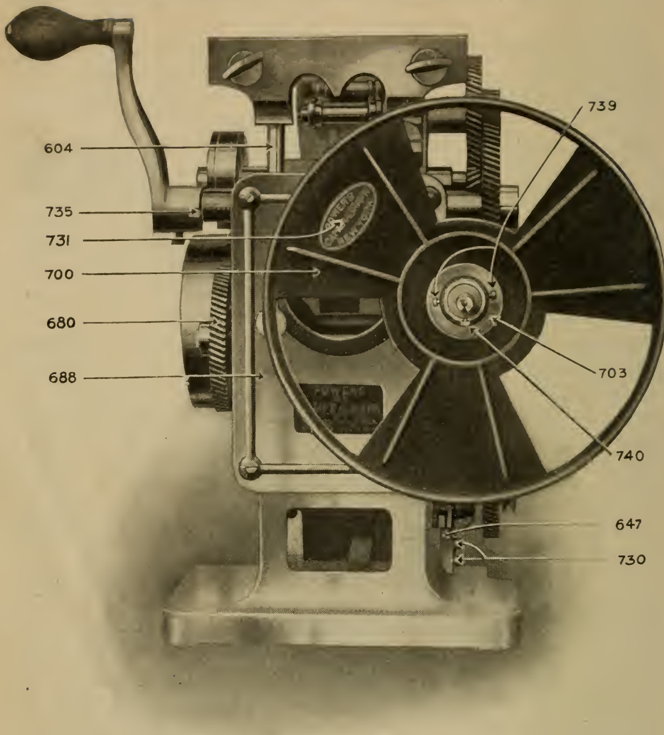


Plate 6.
Fig. 120.

moved the intermittent sprocket shaft, rest the sprocket hub on the end of a small block of wood, and, with a small steel punch, gently drive out the two pins which hold the sprocket to the shaft, being careful to drive them the right way, as they are tapered. After removing the pins, rest the end of the shaft on a block of wood, and with a small piece of hard wood, or a brass or copper punch, holding punch on the sprocket hub close to the shaft, gently drive the sprocket from the spindle. Remember that you are not working with the driving-axle of a locomotive, but with a delicate part which is easily injured, therefore act accordingly. Never drive on the rim of the sprocket, and do not set the end of the shaft on hard metal, or use a steel punch to drive the sprocket off with. Should the pin holes in the new sprocket not exactly fit the holes in the shaft, drill new holes at right angles to the old ones; but before drilling them, place the shaft in position in the machine and line the sprocket exactly with the top and bottom sprocket and the aperture. However, instruction No 40 is by far the better way, except in cases where the theater is equipped to do this kind of work.

No. 42.—Setting Sprocket Idler Rollers. See general instruction No. 12. Idler rollers 609 and 660, P 2, and 657, P 1, should be kept set away from their respective sprockets by about twice the thickness of a film. This is an absolute necessity and failure to attend to it will cause loss of film loops if there is any tendency in that direction. Idler 609, P 2, is adjusted in relation to its sprocket by a small screw just behind the handle on which is the arrow-head from 612, P 2. Screw 719, P 2, adjusts intermittent sprocket roller and screw 724, P 2., adjusts sprocket of lower, or take-up sprocket roller. In adjusting lower, or take-up sprocket roller, if you have the type of bracket carrying two rollers, set the front, or top roller, allowing lower, or back one to come to where it will, provided it does not come closer to the sprocket than twice the thickness of a film. If you have the one-roller type of bracket, then set the roller twice the thickness of a film away from the sprocket. After adjusting roller always set lock-nuts of adjustment screws up tight. Remember that lack of care in adjusting these rollers is likely to cause trouble through losing upper or lower loops.

No. 43.—Worn Aperture Plate Tracks. See general instruction No. 11, page 217.

No. 44.—End Play in Sprocket Idler Rollers. Keep collars, 611, P 2, and 726, P 1, set up snugly against the rollers so that the latter have no end play. Failure to do so may cause damage to sprocket teeth. Don't set them tight enough to bind the rollers, however, Keep rollers set so that grooves are central with teeth. To accomplish this the shaft carrying them may be shifted endwise by loosening screw holding same. It is essential that idler rollers of all sprockets turn freely. If a roller sticks, investigate and remove the cause at once.

No. 45.—Oil for Intermittent Oil Casing. Use a high grade of machine oil in intermittent oil casing and keep same filled to top of oil-cup at all times. This latter applies only to those having oil-cup of type illustrated 673, P 4. Do not use a thin

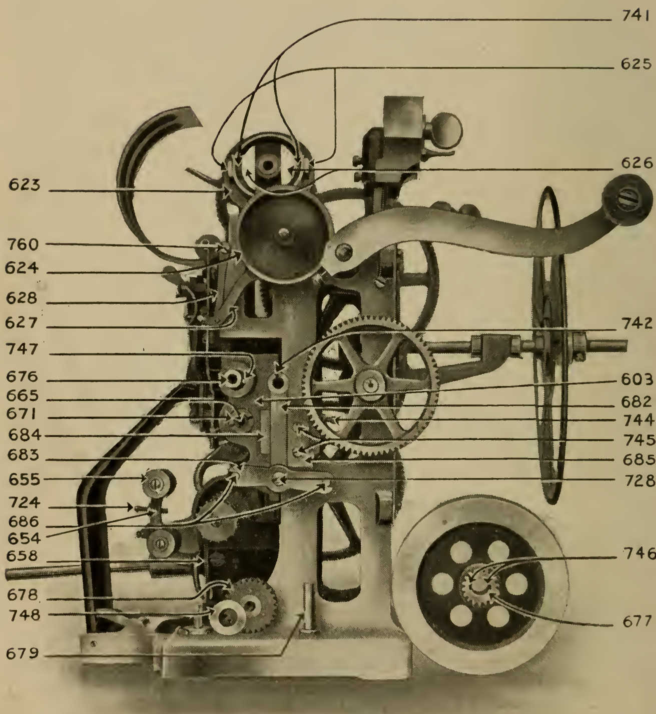


Plate 7.

Fig. 121.

oil in casing. The Nicholas Power Company will supply suitable oil for casing at a reasonable price. I would strongly advise its use, though a high-grade moderately heavy machine oil will produce satisfactory results. See General Instruction No. 1.

No. 46.—Gate-Latch Adjustment. Gate latch-screw, 722 P 2, should be kept set just so as to hold contact screws 760, P 2, on inside of gate, snugly against face of machine.

No. 47.—Aligning Gate with Aperture. If at any time aperture in gate should, from accident or other cause, get out of line with aperture—not central, sidewise, with aperture—the gate may be moved to the left by striking sharply alternately on its upper and lower front edge with a light hammer. It may be moved the other way by tapping on round part of gate hinge, using a brass punch, thus bending hinge slightly. After doing this it may be necessary to line up idlers 691, P 2, with top of aperture plate. They should be set equi-distant from its edges.

No. 48.—End Motion in Intermittent Sprocket. There should be no end motion at all in intermittent sprocket 667, P 2. End motion may be readily eliminated by loosening screw in collar against end of bushing 670, P 2. Holding screwdriver in screw slot, with another screwdriver, or other convenient tool, pry gently against rim of sprocket and collar, forcing sprocket to the right and collar to the left against bushing. While holding the collar over thus, tighten the screw in same. Turn machine very slowly, and if the intermittent movement binds, you have the collar too tight. Insert end of screwdriver through one of the holes in flywheel and against end of intermittent shaft. With hammer tap very lightly. Try machine and do it again, if necessary, trying sprocket each time to be sure you have not loosened it too much. This collar should be just as tight against the bushing as it can be without binding. Side motion in intermittent sprocket is very likely to produce side motion in picture on the screen.

No. 49.—Oil. See general instruction No. 1. The Nicholas Power Co. supplies oil which they have selected after careful test, and which they approve for use with their mechanisms. I would recommend this oil to operators. Its price is quite reasonable.

No. 50.—The Emulsion on Tension Springs. See general instruction No. 10, page 217.

No. 51.—Oil-Holes. In oiling do not overlook oil-holes, 742, P 7, just back of toggle gear, and oil-hole 736, P 5, just back of revolving shutter bracket. Other oil-holes are: One in top sprocket shaft. Two in crankshaft. Three in governor shaft. One in governor friction case. Two for flywheel shaft Two for intermittent sprocket shaft, one for lower sprocket shaft. Oil cup in intermittent oil casing. One for shaft, 681, P 3. Three for revolving shutter shaft, and one for lower magazine take-up spindle.

No. 52.—Automatic Shutter. Should automatic shutter fail to drop, examine lever 627 and connecting link 628, P 7, and see that they work freely and are not bent. Take off cover 623, P 2 (see instruction 28), and see if springs 741, P 7, are in good condition. Also examine inside edge of friction casing 624, P 7, and see if it is as it should be and not rough or scratched.

Should automatic shutter fail to raise properly, first try a drop of heavy oil. The clutch acts by centrifugal force, throwing out weights 626, P 7, overcoming action of springs 741, P 7, and forcing friction shoes 625, P 7, out against interior rim of casing 624, P 7. This revolves casing, 624, P 7, forcing lever 627, P 7, ahead and raising shutter flap 697, P 1. Do not use thin oil in automatic shutter friction casing as it tends to reduce friction too much. Use a heavy oil sparingly.

No. 53.—Clean Sprockets. See general instruction. No. 3.

No. 54.—Anchoring Machine Table. Machine table should be perfectly rigid. To accomplish this, set legs in floor sockets (to be had of Nicholas Power Company), spreading the legs slightly before fastening sockets to the floor. If the table is not set solidly, there may be vibration and a slight swaying of the head under the pressure of the crank which will cause side motion of the picture on the screen. The above applies to the old type of table having telescopic legs and a wooden top. The legs of the new 6A table should also be set in sockets, and the same should be screwed firmly to the floor. See Anchoring the Machine, page 91.

No. 55.—The Film. See general instruction No. 14. The machine is threaded by bringing film down from upper magazine under large roller in front of top sprocket, and up over the sprocket, closing top sprocket idler down on film. Carry film down across aperture and engage sprocket holes with teeth of intermittent sprocket, leaving enough slack so that it will form upper loop of proper size.

Close intermittent idler; then close gate. Next bring film up over lower sprocket and close its idler, leaving a loop between the intermittent and lower sprockets long enough to reach down an inch below top of lower sprocket. Carry end of film on through valve of lower magazine and attach to lower reel in usual way, taking up all slack by revolving lower reel.

No. 56.—Lower Magazine. The lower magazine should be so set that it hangs straight up and down and in line, front and back, with the table. The belt must be crossed so that as you look into the magazine the front of the reel travels down, the reel traveling clockwise.

No. 57.—Take-Up Tension. See general instruction No. 2, page 214; also page 226.

No. 58.—The Lamp. The lamp should not be allowed to become dry from lack of lubrication. It is next to impossible to properly handle the light when using a dry lamp. Once a week take the lamp apart, all but the insulated joints, which should not be disturbed, and grease all screws and moving parts with vaseline, wiping all surplus off. Then drop all screws and moving parts into a box of powdered graphite. Shake off surplus graphite, do not wipe it off, and put lamp together again. You will be surprised at how much better you can handle the light. Keep metal clean where carbons make contact with it. Scrape and clean thoroughly at least once a week. Dirty carbon contacts induce heating and loss of power and light. Be sure the wires make good electrical contact with lamp binding posts. When terminal lugs become burned, throw them away and put on new ones. It does not pay to use burned lugs. When wires inside lamphouse become burned (the life gone out of them), cut away the burned portion. Burned wires cause high resistance and loss. Unless removed they will eventually burn off entirely, causing vexatious delay. The N. Power Co., 90 Gold Street, New York City, will furnish graphite at 75 cents per can.

No. 59.—Setting the Lens. Screws, 704, P 5, holding lens-ring should be loosened after lens is screwed into place and this ring, 714, P 5, should be turned until handle of lens is in most convenient position. The screws may then be set up just tight enough to hold the ring firmly in place. Don't get them too tight, however, as they are of brass and bend easily.

No. 60.—When a new machine is purchased, revolving shutter bracket, 637, P 4, and revolving shutter spindle, 636, P 4, will be found folded down against the frame of the machine. The spindle should be raised up until screw, 732, P 4, engages with the hook on the top of the shutter bracket. Raise the spindle as high as it will go, and, after being sure that the bracket is shoved over tightly against the frame casting, tighten screw, 732, P 4 and 5, and screw 733, P 5. Do not forget screw 733, as it assists in holding bracket securely in place. Keep collars 638, P 4, set up snugly against the boxing, so that spindle 636, P 4, will have no end play.

No. 61.—Revolving Shutter, 700, P 6, should be set in as far as it will go on the shaft, or as far as it will go without striking the lens. In other words, the shutter should be as close to the lens as you can get it without having it strike. It is held to the spindle by screw 740, P 6, which must rest in the V slot in the spindle. Be sure to have screw 740, in the slot in the spindle and to set it up tightly, otherwise your shutter will be out of time. The shutter should be put on the spindle with the hub outward, with stamp 731, P 6, on the front as shown. This stamp indicates wide wing of the shutter, which is the one that cuts off the light during the change of pictures. In other words, it is the effective blade of the shutter. See "The Shutter," page 219.

No. 62.—Travel Ghost—Setting Shutter. Should travel ghost (streaks up or down from letters of titles or flashes of white up or down from white objects in picture) develop at any time, it may be eliminated by resetting the shutter. Loosen one of screws 739, P 6, and slack off on the other one until shutter can be slipped by applying some pressure. If streaks are up, hold flywheel stationary and revolve the top of shutter away from you slightly, and, with a black and white film title in machine, try it. If streaks are down, pull top of shutter toward you. Keep slipping shutter slightly and trying until streaks disappear. Then tighten up screws 739. When travel ghost develops, first be sure screw 740, P 6, is set up tight. To set a new shutter, proceed as follows: Place shutter on shaft as shown in P 6, with hub toward end of shaft. Set screw 740, P 6, in V-slot and tighten it. Loosen screws 739, P 6, so that shutter revolves freely on inner hub. Open gate and turn flywheel *backward* until intermittent sprocket is just at point of moving. Set shutter as shown in P 6 and tighten one of screws 739 slightly. Then proceed as directed for travel ghost. For very short focus lenses the Nicholas Power Company will supply a special shutter on application. Their two blade shutter should be used on 60 cycles A. C. The blade with stamp 731, P 6, on is the wide blade and the only one to be considered at all in setting shutter.

Travel ghost may be caused by (a) screw 740, P 6, loose. (b) Collars 638, P 4, not set up snugly against boxing, thus allowing end play in shutter shaft. (c) Gear 680, P 3, loose on its shaft. (d) Gear 633, P 4, loose on its shaft. (e) Badly worn gears. Anyone of these things, or all combined may cause travel ghost. Screws clamping the shutter blade in the flanges of the hub being loose might also be responsible for such a condition of affairs.

NAMES AND NUMBERS OF PARTS FOR POWER'S No. 6 MACHINE.

Order Parts by Number Only. These Numbers Are the Manufacturer's Regular Stock Numbers.

First column of figures indicates the plate number.

3 —601 Main Frame Casting.
4 602 Top Frame Casting, including thumbscrews.
7 —603 Framing Carriage.
4 & 6—604 Top Frame Supporting Rods.
5 —605 Stereo Bracket Holder with Thumbscrews.
0 —606 Stereo Bracket with Thumbscrews.
0 —607 Stereo Collar Casting.
0 —608 Stereo Lens Rod.
2 —609 Small Upper Roller.
2 —610 Small Upper Roller Spindle.
2 —611 Set Collar for Small Top Roller.
2 —612 Upper Roller Bracket.
3 & 5—613 Large Upper Roller.
3 —614 Large upper roller spindle.
2 —615 Upper roller bracket spring
3 —616 Set Collar for Large Top Roller.
2 —617 Upper Sprocket.
2 & 3—618 Upper Sprocket Spindle.
1 & 4—619 Upper Sprocket Feed Gear (large).
1 & 4—620 Upper Sprocket Feed Gear (small).
4 —621 Pinion for Automatic Shutter Spindle.
2 & 3—622 Spindle for Automatic Shutter.
2 & 7—623 Friction Case Cover for Automatic Shutter.
2 & 7—624 Friction Case for Automatic Shutter.
7 —625 Friction Shoe with Spring for Automatic Shutter.
7 —626 Friction Weight for Automatic Shutter.
2 & 7—627 Lever for automatic shutter.
2 & 7—628 Link for Automatic Shutter.
2 —629 Counter-Weight for Automatic Shutter.
4 —630 Crank Shaft Driving Gear.
3 & 5—631 Crank Shaft.
3 & 5—632 Crank with Handle, complete.
4 —633 Small Gear Meshing in Driving Gear.
4 —634 Large Gear for Revolving Shutter.
4 —635 Small Gear for Revolving Shutter.
4 —636 Spindle for Front Shutter.
4 —637 Bracket for Revolving Shutter.
4 —638 Set Collars (2) for Front Shutter Spindle.
0 —639 Stud with Screw for Front Shutter Bracket.
4 —640 Large Idler Gear.
5 —641 Large Idler Gear Spindle.
5 —642 Large Idler Gear Spindle Set Collar.
2 —643 Take-up Feed Pinion.
2 & 4—644 Take-up Feed Pulley.
3 —645 Take-up Feed Spindle.
2 —646 Take-up Feed Sprocket (same as No. 617).
4 —647 Framing Device Clamp.
4 —648 Framing Lever Socket.
4 —649 Framing Lever Socket Link.
4 —650 Framing Lever.
4 —651 Framing Device Screw.
5 —652 Framing Device Wing Nut.
5 —653 Take-up Roller Bracket.
3 & 7—654 Take-up Roller Carrier.
7 —655 Take-up Spindle.
0 —656 Set Collar for Small Spindle (same as No. 611).
1 —657 Take-up Roller.
2 & 7—658 Take-up Roller Bracket Spring.
2 —659 Intermittent roller bracket
2 —660 Intermittent Roller.
2 —661 Intermittent roller bracket spindle.
0 —662 Intermittent Set Collar for Shaft.
2 — 663 Intermittent Spring.
2 —664 Contact Screws in Gate.
7 —665 Intermittent Spindle.
0 —666 Pin Cross (with Spindle No. 665).
2 —667 Intermittent Sprocket.
0 —668 Gate Spring Support.
1 & 2—669 Apron complete with roller
2 —670 Intermittent Bushing (large).
7 —671 Intermittent Bushing (small).
3 —672 Fly-wheel.
4 —673 Oil Cup for Intermittent Movement.
4 —674 Cover for Intermittent Movement.
0 —675 Cam for Intermittent Movement.
2 & 7—676 Cam Shaft.
1 & 7—677 Fly-wheel Pinion.
1 & 7—678 Toggle Joint Idler Gear.
7 —679 Toggle Joint Idler Gear Spindle.
3 —680 Driving Gear for Idler 678.
3 —681 Driving Gear Spindle.
3 & 7—682 Connecting Link.
3 & 7—683 Small Horizontal Lever.
7 —684 Large Guide Casting.

3 & 7—685 Small Casting.
3 & 7—686 Studs for horizontal lever.
2 —687 Aperture Plate.
5 & 6—688 Front Plate.
1 —689 Gate.
1 —690 Hinge for Gate.
2 —691 Gate Guide Rollers.
2 —692 Guide Roller Bushing, Spring and Spindle.
1 —693 Latch for Door.
2 —694 Tension Shoe.
4 —695 Gate Hinge Pin.
1 —696 Cooling Plate.
1 —697 Flap for automatic shutter
1 —698 Rock Shaft for Automatic Shutter.
2 —699 Carriage Guide Rods.
6 —700 Outside Revolving Shutter Blade.
3 —701 Outside Revolving Shutter Bushing (large).
3 —702 Outside Revolving Shutter Bushing (small).
6 —703 Outside Revolving Shutter Flange Complete.
5 —704 Lens Ring Screws.
1 & 2—705 Upper Film Shield.
2 & 4—706 Lower Film Shield.
2 —707 Spindle for Lower Film Shield.
2 & 4—708 Lower film shield bracket.
3 —709 Fly-wheel Spindle Screw.
4 —710 Upper Roller Bracket Screw with Nut.
0 —711 Roller for apron (3 pieces)
0 —712 Rock Shaft for Take-up Roller Carrier.
2 —713 Screws (4) for Aperture Plate.
5 —714 Lens Ring.
1 —715 Screw Holding Intermittent Roller Bracket.
2 —716 Lower Film Shield Spring.
1 —717 Screws Holding Take-up Bracket Spring.
2 —718 Screw Holding Governor Cover to Shaft.
2 —719 Screw to Adjust Intermittent Sprocket Rollers.
2 —720 Stud and Nut Holding Upper Roller Bracket.
2 —721 Screw Holding Upper Sprocket Roller Spindle.
2 —722 Gate Latch Screw and Nut.
2 —723 Screw Holding Right Hand Intermittent Shaft Bushing.
2 —724 Screw to Adjust Lower Sprocket Rollers (with nut).
1 —725 Screw Holding Take-up Roller Bracket.
1 —726 Collars on Lower Bracket Spindles.
3 —727 Screws Holding Top Frame Casting Support Rods.
3 & 7—728 Screws Holding Horizontal Lever.
2 —729 Spring for Gate Roller Guides.
6 —730 Screws (2) Holding Framing Device Clamp.
6 —731 Stamp on Wide Wing of Shutter.
4 & 5—732 Upper Screw Holding Revolving Shutter Bracket.
5 —733 Lower Screw Holding Revolving Shutter Bracket.
1 —734 Screw for Adjusting Tension Shoes.
6 —735 Pin Through Crank Shaft.
5 —736 Oil Hole back of Shutter Bracket.
5 —737 Magazine thumb screws (2)
2 —738 Set Screws for Sprockets.
6 —739 Screws (2) in Outer Shutter Hub.
6 —740 Screw Holding Revolving Shutter to Shaft.
7 —741 Springs (2) for Automatic Governor Friction Shoe.
7 —742 Oil Hole for Toggle Gear Idler.
1 —743 Screw Holding Left Hand Intermittent Shaft Bushing.
7 —744 Set Screws (2) to Tighten Connecting Link 682.
7 —745 Screws (2) Holding Casting 685 against Connecting Link.
7 —746 Slots in Fly-Wheel Pinion.
7 —747 Pin to Engage in Slots 746.
7 —748 Washer between Fly-wheel Pinion and Boxing.
4 —749 Oil Casing Cover Screws (3 of them).
0 —750 Screws (2) Holding Apron 869.
3 —751 Screw in Hub of Crank.
4 —752 Screw Holding Top End of 628.
1 —753 Screws (2) Holding Upper Fire Shield.
5 —754 Screws (4) Holding Front Plate.
2 —756 Screws (2) Holding Tension Shoes.
1 —757 Gate Hinge Screws (3).
1 —758 Screws (4) Holding Lower Fire Shield Bracket.
0 —759 Screws Holding Roller Idler Spindles to Bracket.
2 —760 Screw Holding Top End 628.

The Simplex Machine

No. 1.*—To Remove the Film Gate, 159, P 2.—Lift it straight upward, unhooking the gate 159, P 2, from pins YY, P 5. The gate will disengage when raised. Should it stick, tap upward lightly on bottom of gate.

No. 2. To Remove Intermittent.—To take out whole intermittent movement remove screw 8, P 3, pull off gear 6, P 3. Push in on film trap screw 166, P 2, which opens gate 159, P 2. Next remove the lower right hand front section of machine cover —the section with curved top immediately below the aperture, same being represented by dotted lines on P 2. This section of the cover is held by four screws. Next loosen screws 53, P 2 and 4, and push back locks 52, P 2 and 4, so that they no longer engage ring of framing cam 92, P 1. Loosen screw 21, P 5, grasp fly wheel 57, P 3, with right hand and pull straight outward, at the same time pulling out gear 19, P 3, with the left hand. You thus remove the entire intermittent casing, fly wheel and intermittent sprocket. In replacing same, reverse the process of removal step by step, first reading instruction No. 8 carefully. In replacing front curved section of machine cover or casing, *be sure to place the shortest screw of the four in the top hole.* If one of the longer ones is used in the top hole it will extend through and tear the film.

No. 3. Adjusting the Star and Cam.—Intermittent sprocket 68, P 1, should have just a little lost motion. If set up too tight there is some danger that binding or undue friction will occur. If the adjustment is made while the machine is cold there will naturally be some slight expansion when the parts become warm through friction and by reason of some heat transmitted through the metal from the spot. After a time, however, by reason of wear of star and cam, the play in sprocket 68, P 1, may become too great. This has a tendency to render the picture unsteady, and it must then be taken up by setting star 67, P 5, closer to cam 62, P 5. It is done as follows: loosen two screws 55, P 4 and 5. Grasp hexagon nut XX, P 5, with a plier or 3/8 flat wrench and turn same slightly either way until the lost motion in the sprocket is almost taken up, leaving just a little bit of play. Tighten screws (2) 55, P 4 and 5, again.

*See page 420 for Key.

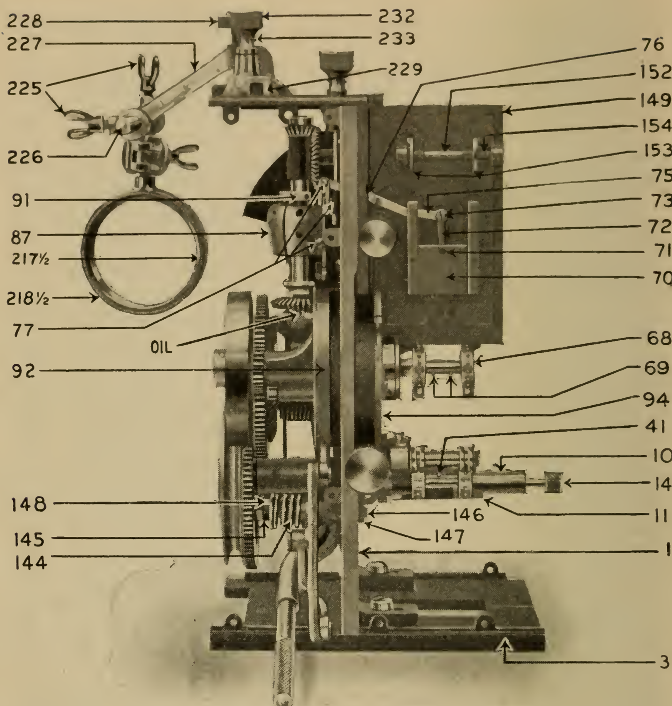


Plate I.
Fig. 122.

No. 4. Removing and Replacing Intermittent Sprocket.— The teeth of intermittent sprocket 68, P 1, do all the work of pulling down the film, working against the pressure of the tension shoes 160 and 161, P 5. They must therefore be expected to wear. When the sprocket teeth become undercut, that is to say, having a groove worn in the surface presented to the film, the sprocket should be removed and a new one installed. It is a good plan to have an eccentric bushing, 54, P 5, star and spindle, 67, P 5, and intermittent sprocket 68, P 1, already assembled as shown in P 5, ready to place in the machine when required. The old sprocket may be replaced at leisure, this being done as follows: Loosen two screws, 55, P 5, and, grasping intermittent sprocket, pull straight out, thus removing bushing, star, spindle and sprocket from the casing. Next carefully remove sprocket from spindle. To do this first remove taper pins 69, P 1, which hold the sprocket to the shaft and with a cloth in the left hand, grasp star and bushing firmly, while with the right hand you pull the sprocket from its spindle with a twisting motion. Should the sprocket stick you may lay the edges on a vise and with a brass or copper punch gently drive the spindle out. Be careful, if the sprocket is a good one, that you do not ruin it in the process, as its rim is thin and easily battered or bent. In installing the new sprocket be very sure that the large diameter of the pin holes in shaft and sprocket are together. To replace parts in the machine first wipe the bushing and its bearings perfectly clean and lubricate with good clean oil. Push the bushing into its bearing until the star is against the cam; turn the fly wheel slowly, at the same time pushing in on the sprocket, until pin on cam 62, P 5, engages with star slot, when bushing may be pushed home; after which adjust star to cam as per instruction number 3 and tighten up the two screws 55, P 5.

No. 5. To Remove Intermittent Casing Cover, 50, P 5.—First follow instructions No. 2 and 4; next insert steel punch in hole X, P 5, and using it as a wrench unscrew the cover from casing. The screw of cover O, P 5, is an ordinary right hand thread.

No. 6. To Remove Cam, 62, P 5.—First follow instructions Nos. 2, 4 and 5; then remove taper pin holding collar 63, P 5, and pull collar off. The cam and its spindle may then be pulled out.

No. 7. To Remove Flywheel Shaft, 59, P 3.—First follow instructions Nos. 2, 4, 5 and 6; then drive out taper pin 58, P 3, pull off fly wheel and shaft will slip out.

No. 8. Replacing Bushing, 54, P 5, and Intermittent Casing, 49, P 5.—This is a very simple operation; it is, however, of great importance that it be rightly done. Both the casing and bushing fit in their bearings very closely. It is therefore necessary that they, as well as their bearings, be cleaned perfectly and lubricated with a good clean oil. Having done this, push the casing or bushing carefully into place, turning or shaking it slightly if it sticks. Never under any circumstances attempt to drive the parts home. You will simply ruin both bearings and casings, or bushings, if you do.

No. 9. To Replace Intermittent Casing, 49, P 5, in the machine, first follow instruction No. 8; then insert shaft of gear 19, P 3, into its bearing about ¼ inch. Next insert casing 49, P 5, into its bearing, and push both casing and gear into place

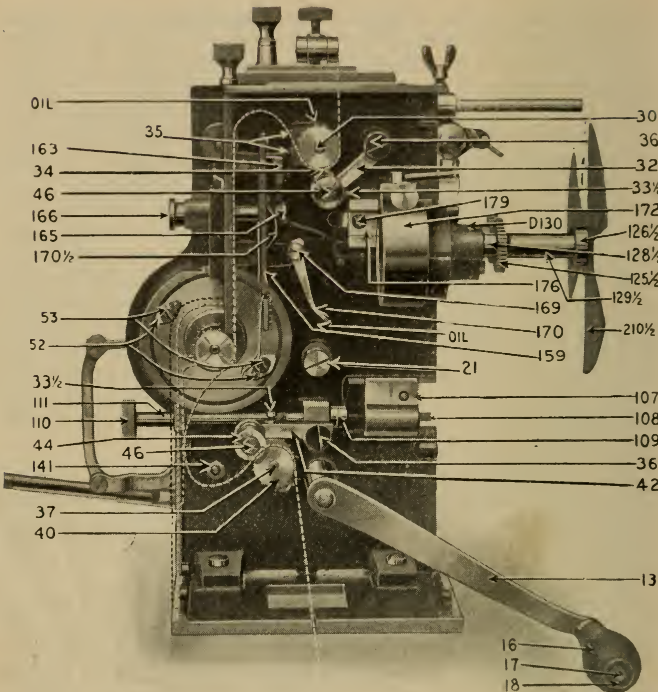


Plate 2.
Fig. 123.

together, having the rim of casing in such position that locating-pin 93, P 4, enters hole in casting rim. The rest of the operation is simply a reversal of instruction No. 2. See that the clutch 7, P 4, locks with its mate properly when gear 6, P 3, is pushed into place.

No. 10. To Remove Gear, 24, P 4, or the Complete Governor or Vertical Shaft, 23, P 4.—Drive out taper pin in hub of double gear 24, P 4, using a light hammer and punch to prevent bending the vertical shaft. This pin is in the hub between upper and lower rows of teeth of the gear. Next remove taper pin 91, P 1, and, grasping gear 25, P 4, pull upwards. Vertical shaft 23, P 4, will come out, thus releasing the other parts.

No. 11. To Remove Spiral Gear, 117, P 4.—First follow instruction No. 10; then remove taper pin holding collar 118, P 4, and pull shaft out to the right.

No. 12. To Remove Spiral Gear, 120, P 4.—Drive taper pin out of left hand end of gear. Spindle will then slip out to the left, thus releasing gear.

No. 13. To Remove Shutter Gear Bracket, 131, P 3.—First follow instruction No. 12, then remove the two screws 133, P 3, and bracket will come off.

No. 14. To Remove Shaft of Outside Revolving Shutter, head of which is shown at 127½, P 5, loosen set screw 130, P 2 and 3, and the shutter and all may be pulled off.

No. 15. To Remove Shutter Blade, 210½, P 5.—Take out the three screws 210, P 5.

No. 16. Gear, 125½, P 2 and 5.—*Do not attempt to remove this gear. It is forced on the shaft under pressure and cannot be removed except at the factory.*

No. 17. To Remove Shutter Adjusting Slide Block, 197, P 2.—Remove taper pin near outer edge of the lower track or slide and turn the knob 110, P 2, to the left until sliding block 107, P 2, is released.

No. 18. To Remove Shaft, 108, P 2.—Insert steel punch in hole in the outer one of the two locking collars, 109, P 2, and, holding punch stationary, turn knob 110, P 2, to the left, which will unlock the collars. Remove the collars and the shaft may be pulled out.

No. 19. To Remove Focusing Slide, 176, P 2, which carries lens holder 172, P 2.—First remove bracket 131, P 3 (see instruction No. 13), then remove screw 179, P 2, and the slide will come out. On bottom there will be found a small gib which provides tension. Be sure to replace this gib when putting the parts together again.

No. 20. To Remove Framing Cam, 92, P 1 and 4.—Take out upper screw 143, P 3. Remove gate, as per instruction No. 1. Remove upper screw 77, P 1, and screws 151, P 4, which release the film trap 149, P 1. Loosen screw 95, P 5, unscrewing ring 94, P 1, and the cam may then be pulled out to the left. The framing cam is the large ring-bearing in which the intermittent casing 49, P 5, rests. To replace same, just reverse the process; screwing up ring 94, P 1, until cam has end play, after which set up screw 95, P 5, tight, as this is the screw which locks ring 94, P 1, in place.

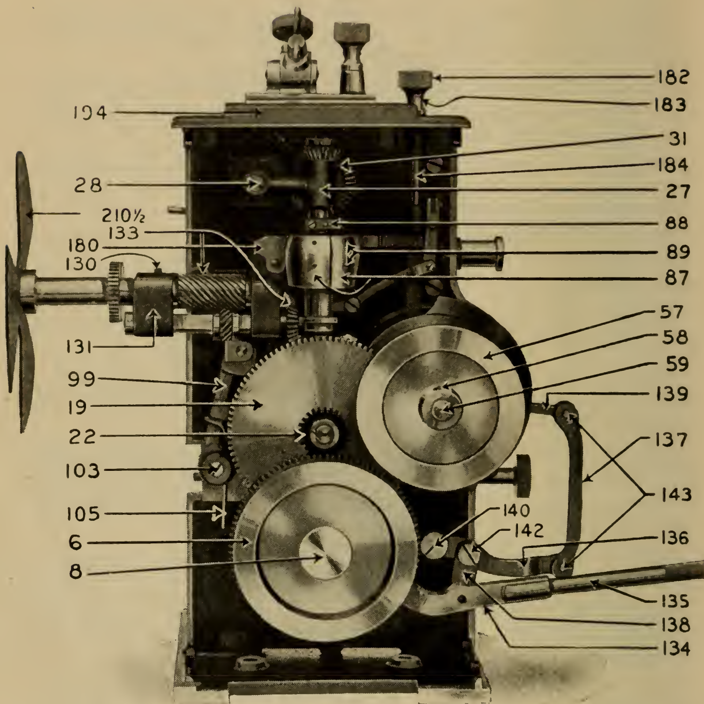


Plate 3.
Fig. 124.

No. 21. To Remove Automatic Fire Shutter Lift Lever, 75, P 1.—First remove screw, 73, P 1, and upper screw, 77, P 1. Next remove film trap 149, P 1, as per instruction No. 20. Drive out straight pin 76, P 1, from behind. This releases the lever.

No. 22. To Remove Governor Lift Lever, 80, P 4.—Remove lower screw 77, P 1, and screw 81, P 4.

No. 23. To Remove Framing Slide Lever, 99, P 3.—First remove gears 6 and 19, P 3, and intermittent casing, as per instruction No. 2. Loosen screw 108½, P 5, which allows you to pull out lever 99, P 3, carrying spring 105, P 3, with it. This also releases framing slide arm 96, P 4, carrying roller 97, P 4, which may be pulled out after lever 99, P 3, has been removed.

No. 24. Spring, 105, P 3.—This spring is for the purpose of holding roller 97, P 4, against the framing cam 92, P 4. It also holds lost motion out of parts between lever and framing cam. To remove the spring take out screw 103, P 3, which releases the spring. To replace, put it on its stud in same position as it was; then bend the free end around to the right until it enters slot in end of stud. Place washer on and replace screw 103, P 3, setting it up tight.

No. 25. Framing Lever Tension Spring, 144, P 1.—This spring causes framing handle, or lever, 135, P 3, to work hard or easy, according to how it is adjusted. If lever 135, P 3, works too hard, this spring has too much tension; if too easy there is not enough. Tension of the spring is governed by nuts 145, P 1. To change the tension, first remove screw 8, P 3, and pull off gear 6, P 3. Loosen outer one of nuts 145, P 1, and tighten or loosen inside nut until the lever works to suit you, after which lock the nuts tightly together again.

No. 26. Film Trap Gate Holder, 163, P 2, is held in place by film trap gate holding stud 165, P 2, which runs through and is held by a screw 166, P 2, inside of which screw is a coil spring, 168 (not shown on plate), which holds the gate against film trap 149, P 1. All these parts may be readily removed as follows: Place a piece of cloth, or paper, between the jaws of a pair of pliers, to prevent marring the metal and unscrew 166, P 2, thus releasing the spring and stud 165, P 2. The metal thimble on screw 166, P 2, is merely to protect and hold the coil spring in proper position. If it is desired to remove the gate holder and stud also, you must take off the film trap (see instruction No. 20).

No. 27. Film Trap Shoes, 155 and 156, P 5, may in time wear. They may be removed by taking out four screws in front of the film trap which holds them in place. These shoes are right and left, and you cannot insert them incorrectly. When ordering, however, take this into consideration. Should the screws project through when new shoes are installed, they must be carefully dressed down flush with surface of the shoe, using a fine file, same also applying to film trap gate shoes 160½ and 161½, P 5.

No. 28. Intermittent Sprocket Tension Shoes, 160 and 161, P 5, are made of spring steel. They hold the film in contact with intermittent sprocket 68, P 1, their adjustment is therefore important. They must be set so that their curved portion just barely touches the sprocket rim. It must, however, be observed that the inside half of each shoe is offset so that it is away from the sprocket slightly when the outer edge touches. Set by the outer half only. Look at the shoes occasionally and see that they are in proper adjustment.

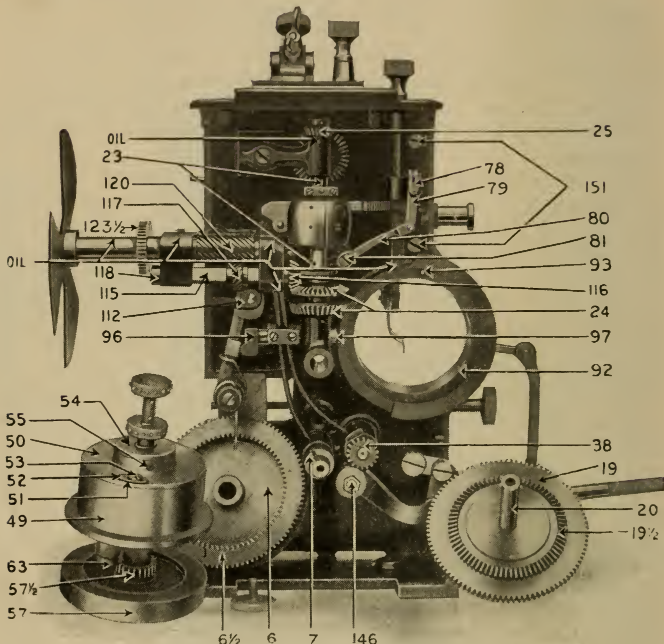


Plate 4.
Fig. 125.

No. 29. **Lens Holder, 172, P 5,** may be shifted forward or backward on sliding block 176, P 2, by loosening clamp screw 173, P 5, by means of handle 174, P 5. In installing new lens, place sliding block 176, P 2, in center of its travel by means of focusing knob 182, P 3. Place lens in adapter ring 172½, P 5. These rings are made to fit various sizes of lenses. Loosen screw 173, P 5, by means of handle 174, P 5, and slide holder back and forth until edges of aperture appear in sharp focus on the screen. Tighten screw 173, P 5, and complete focusing by means of knob 182, P 3. Tube projection lenses only can be used on the Simplex machine. It is therefore necessary to purchase a lens jacket.

No. 30. Upper and Lower Sprocket Idlers, 44, P 5 and 2, must be carefully adjusted in relation to the sprockets. The upper idler is adjusted by means of screw 33½, P 2. That of the lower idler is adjusted by a similar screw 33½, P 2. These rollers must be kept set away from the sprockets by about twice the thickness of a film. If set too close it has a tendency to cause the film to run off the sprockets. If too far away it may cause the sprocket holes to climb, that is, the film may slip over. In either event the effect is to lose the loops. It will be seen that these adjustments are of the utmost importance. After making adjustment be sure that you set up the adjusting-screw lock nuts tightly.

No. 31. Roller Arm Tension Springs.—Upper sprocket roller arm 32, P 2, is held against sprocket by means of a spring clamped under screws 35, P 2. To remove this spring, take off film trap 149, P 1, as per instruction No. 20. The lower roller arm spring 43, P 5, is held by two screws which may be removed through the bottom roller holder opening in base of the machine, when same is removed from table.

No. 32. Aperture Size.—The Simplex aperture is exactly 11/16 by 15/16 of an inch. These dimensions may be used in figuring lenses for this machine.

No. 33. Oil.—It is well to avoid the use of widely advertised patent oils. As a rule they are totally unfit for use on a motion picture mechanism. Some of them possess little or no lubricating qualities. Best results are obtained by use of a good grade of light dynamo oil. A heavier lubricant is best for gears. For gears a heavy automobile cylinder oil is recommended. Purchase oil in quantities from a reliable dealer. Vaseline may be used for gears, but cylinder oil is better, both as to preservation of the machine, and cleanliness.

No. 34. Washing Gears and Bearings.—Simplex gears and bearings are well protected from dust and dirt, still it is not a bad plan to wash them thoroughly with kerosene, benzine or gasoline once each week. Use an ordinary oil can filled with kerosene, benzine or gasoline, and flooding the gears and bearings thoroughly while turning the crank. Use rags under the gears to catch the dirty oil as it runs off the machine, or use a pan which should be placed underneath.

No. 35. Setting the Shutter.—The revolving shutter is set while the machine is in operation by turning knob 110, P 2. If streaks show at top or bottom of letters in titles or flashes up or down from any white object in film, it is evident that the shutter

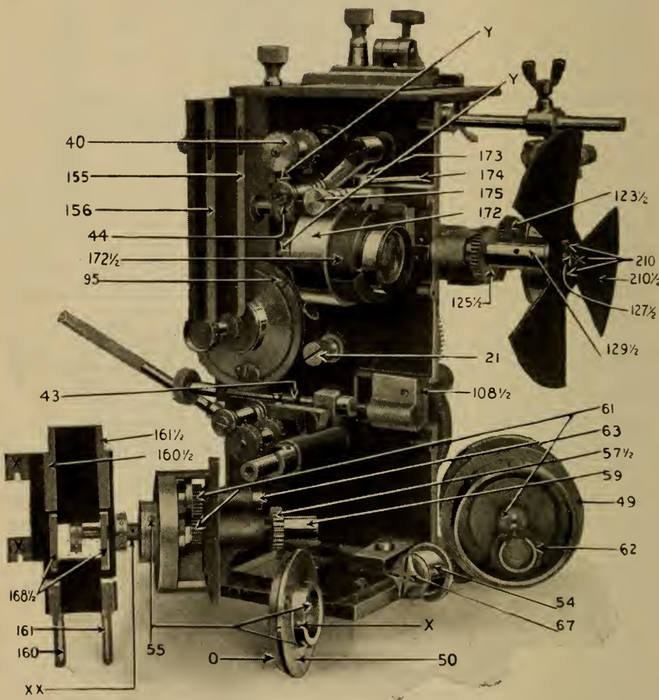


Plate 5.
Fig. 126.

is out of adjustment. Turn knob 110, P 2, one way or the other until the streaks disappear.

No. 36. Focusing Lens.—The picture on the screen is readily focused by turning knob 182, P 3, which moves the projection lens closer to or farther from the film according to the way it is turned.

No. 37. Clean Sprockets.—If you expect the picture to be steady it is absolutely essential that you keep intermittent sprocket 68, P 1, clean. Dirt or gum on its face will cause the picture to become unsteady and vibrate. Also the upper and lower sprockets, 40, P 5 and 2, should be kept perfectly clean since gum or dirt on their surface has a tendency to cause the film to run off the sprocket and thus lose the loops. A tooth brush is best for cleaning sprockets. All sprockets should be cleaned thoroughly at least once every day.

No. 38. Tension Shoes 168½, P 5, provide tension to stop the film and hold it flat and stationary over the aperture during exposure. When first run films are used there is a decided tendency for the soft emulsion to deposit on these shoes and this deposit must be carefully removed after every run. Never use a knife blade or steel instrument to clean the shoes else you may scratch them and make matters worse. Use a wet rag or scrape with a silver coin or some soft metal article. A little tallow rubbed on before each run will help to prevent emulsion depositing but nothing will entirely prevent it. This trouble usually occurs only with first run films. Tension for shoes 168½, P 5, is provided by spring 170½, P 2. The tension is constant and can only be varied by bending the springs. It shou'd be more than just enough to prevent the picture from climbing up on the screen when crank speed is increased to about 90 revolutions per minute. More than this only wears the sprocket holes of the film and the mechanism of the machine uselessly.

No. 39. Stereopticon Lens.—The stereo lens will be placed in its mount and clamped in place by ring 218½, P 1. To adjust lens loosen wingnuts 225, P 1, and slide the lens and mount either forward or backward on rod 226, P 1, until picture is in approximate focus on screen. Tighten wingnuts 225, P 1, again and complete focusing with knob 232, P 1. The stereo lens can be raised or lowered by means of knob 228, P 1, thereby centering the picture on the screen.

No. 40. Oil Holes Will Be Found, as indicated on the various plates.

No. 41. Threading.—The course of the film through the machine is shown by the dotted white line on P 2.

NAMES AND NUMBERS OF PARTS FOR THE SIMPLEX MECHANISM.

Order Parts by Number Only. These Numbers Are the Manufacturers' Regular Stock Numbers. The First Column of Figures Indicates the Plate on Which the Part Is Shown.

1 & 2—	1	Centre Frame.
	2	Centre Frame Screws (2)
1 —	3	Base.
	4	Base Wing Screws (2).
	5	Base Dowel Pins (2).
3 & 4—	6	Main Driving Gear (spur).
4 —	6½	Main Driving Gear (Internal).
4 —	7	Main Driving Gear Clutch.
3 —	8	Main Driving Gear Retain Screw.
	9	Main Driving Gear Clutch Pin.
1 & 2—	10	Crank Shaft.
1 —	11	Crank Driving Collar.
	12	Crank Driving Collar Pin.
2 —	13	Crank.
1 —	14	Crank Retain Screw.
	15	Crank Retain Plug.
2 —	16	Crank, Wood Handles.
2 —	17	Crank Stud.
2 —	18	Crank Washer.
3 & 4—	19	Intermediate Gear No, 2 (spur).
4 —	19½	Intermediate Gear (bevel).
4 —	20	Intermediate Shaft.
2 & 5—	21	Intermediate Shaft Retain Screw.
2 —	22	Intermediate Gear No. 1.
	22½	Washers on Intermediate Gear.
4 —	23	Vertical Shaft.
4 —	24	Double bevel gear No. 2.
4 —	25	Bevel Gear No. 3.
	25½	Bevel Gear Taper Pin.
	26	Vertical Shaft Washer.
	26½	Vertical Shaft Washer No. 2.
3 —	27	Vertical Shaft Bracket.
3 —	28	Vertical Shaft Bracket Screw.
	29	Vertical Shaft Bracket Pin.
2 —	30	Top Sprocket Shaft.
3 —	31	Bevel Gear No. 4.
	31½	Bevel Gear Taper Pin.
2 —	32	Upper Sprocket Roll Arm.
	33	Upper and Lower Sprocket Roll Arm Pins (2).
2 —	33½	Upper and Lower Sprocket Roll Arm Screws (2).
2 —	34	Upper Sprocket Roll Arm Spring.
	35	Upper and Lower Roll Arm spring screws (4).
	35½	Upper and Lower Roll Arm Nuts (2).
2 —	36	Upper and Lower Roll Arm Pivot Screws (2).
2 —	37	Lower Sprocket Shaft.
4 —	38	Lower Sprocket Gear.
	39	Lower Sprocket Shaft Washer.
2 & 5—	40	Upper and Lower Sprockets.
2 —	41	Upper and Lower Sprocket Pins (2).
	42	Lower Sprocket Roll Arm.
5 —	43	Lower Sprocket Roll Arm Spring.
2 & 5—	44	Pad Rollers (2).
	45	Pad Roller Studs (2).
	45½	Oil Tube for Crank Shaft.
2 —	46	Pad Roller Screws (2).
	46½	Oil Tube.
4 & 5—	49	Intermittent Case.
4 & 5—	50	Intermittent Case Cover.
4 —	51	Intermittent Case Cover Locks (2).
4 —	52	Intermittent Case Cover Lock Pins (2).
4 —	53	Intermittent Case Cover Lock Screws (2).
4 & 5—	54	Intermittent Case Eccentric Bushing.
4 & 5—	55	Intermittent Case Eccentric Bushing Set Screws (2).
4 —	56	Intermittent Case Oil Cup.
3 & 4—	57	Fly Wheel.
4 & 5—	57½	Fly Wheel Gear.
3 —	58	Fly Wheel Taper Pin.
3 & 5—	59	Fly Wheel Shaft.
	60	Fly wheel shaft washer.
5 —	61	Star Wheel Cam Spur Gears (2).
5 —	62	Star Wheel Cam & Shaft.
4 & 5—	63	Star Wheel Cam Collar.
	64	Star Wheel Cam Collar Taper Pin.
	65	Star Wheel Cam Pin.
	66	Star wheel Cam Washer
5 —	67	Star Wheel & Shaft.
1 —	68	Intermittent Sprocket Wheel.
1 —	69	Intermittent Sprocket Wheel Taper Pins (2).
1 —	70	Auto. Fire Shutter.
1 —	71	Auto. Fire Shutter Stud.
1 —	72	Auto, Fire Shutter Lift Link.
1 —	73	Auto. Fire Shutter Lift Link Retain Screw.
	74	Auto. Fire Shutter Lever Stud.

1	— 75	Auto. Fire Shutter Lever.
	76	Auto. Fire Shutter Lever Pivot Pin.
1	— 77	Auto. Fire Shutter Link Hinge Screws (3).
4	— 78	Governor Lift Lever Connecting Link.
4	— 79	Governor lift lever link.
4	— 80	Governor Lift Lever.
4	— 81	Governor Lift Lever Pivot Screw.
	82	Governor Lift Lever Stud.
	83	Governor Lift Lever Roller.
	84	Governor Lift Lower Link Holder .
	85	Governor Weight Stop.
	86	Governor Weight Links (4).
1 & 3	— 87	Governor Weights (2).
3	— 88	Governor Top Link Holder.
3	— 89	Governor Weight Screws (4).
	90	Governor Link Holder Screws (4).
1	— 91	Governor Link Holder Pin.
4 & 1	— 92	Framing Cam.
4	— 93	Framing Cam Locating Pin.
1	— 94	Framing Cam Adjusting Ring.
5	— 95	Framing Cam Adjusting Ring Screw.
4	— 96	Framing Slide Arm.
4	— 97	Framing Slide Arm Roller.
	96	Framing Slide Arm Roller Pin.
3	— 99	Framing Slide Lever.
	100	Framing Slide Lever Block.
	101	Framing Slide Lever Pin.
	102	Framing Slide Lever Stud.
3	—103	Framing Slide Lever Stud Screw.
	104	Framing Slide Lever Stud Set Screw.
3	—105	Framing Slide Lever Spring.
	106	Framing Slide Lever Stud Washer.
2	—107	Shutter Adjusting Slide.
2	—108	Shutter Adjusting Screw.
5	—108½	Shutter Adjusting Slide Screw.
2	—109	Shutter Adjusting Screw Collars (2).
2	—110	Shutter Adjusting Screw Knob.
2	—111	Shutter Adjusting Screw Knob Pin.
4	—112	Framing Slide.
	113	Framing Slide Guide Rod.
	114	Framing Slide Set Screw.
4	—115	Spiral Gear Driving Shaft.
4	—116	Shutter Driving Bevel Gear.
4	—117	Spiral Driving Gear with broached hole.
4	—118	Spiral Gear Driving Shaft Collar.
	119	Spiral Gear Driving Shaft Collar Pin.
4	—120	Spiral Gear.
	121	Spiral Gear Shaft.
	122	Spiral Gear Pin.
4 & 5	—123½	Intermediate Shutter Gear.
	124	Intermediate Shutter Gear Pin.
	125	Intermediate Shutter Gear Bushing.
2 & 5	—125½	Shutter Blade Spur Gear.
2	—126½	Shutter Blade Gear Collar.
5	—127½	Shutter Blade Gear Stud.
2	—128½	Shutter Blade Gear Bushing.
2 & 5	—129½	Shutter Blade Gear Distance Piece.
2 & 3	—130	Shutter Blade Gear Set Screw.
3	—131	Shutter Gear Bracket.
	132	Shutter Gear Bracket Pin.
	133	Shutter Gear Bracket Screws (2).
3	—134	Picture Framing Handle Arm.
3	—136	Picture Framing Lever.
3	—137	Picture Framing Connecting Link.
3	—138	Picture Framing Link.
3	—139	Picture Framing Arm.
3	—140	Picture Framing Lever Pivot Screw.
2	—141	Picture Framing Lever Pivot Screw Nuts (2).
3	—142	Picture Framing Link Screws (2).
3	—143	Picture Framing Conn. Link Screws (2).
1	—144	Picture Framing Handle Friction Spring.
1	—145	Picture Framing Handle Friction Spring bet. nuts (2).
1 & 4	—146	Picture Framing Handle Pivot.
1	—147	Picture Framing Handle Pivot Nut.
1	—148	Picture Framing Friction Washer.
1	—149	Film Trap.
	150	Film Trap Locating Pins (2).
4	—151	Film Trap Screws (2).
1	—152	Lateral Guide Roller Shaft.
1	—153	Lateral guide rollers (2).
1	—154	Lateral Guide Roller Spring.

5	—155	Film Trap Shoe, Right (Inside).
5	—156	Film Trap Shoe, Left (Outside).
	157	Film Trap shoe screws (8).
	158	Film Trap Bushing.
2	—159	Film Trap Gate.
5	—160	Intermittent Sprocket Shoe, Right, (Inside).
5	—160½	Film Trap Gate Shoe, Right (Inside).
5	—161	Intermittent Sprocket Shoe, Left (Outside).
	162	Film Trap Gate Tension Screws (8).
2	—163	Film Trap Gate Holder.
	164	Film Trap Gate Holder Pins (2).
2	—165	Film Trap Gate Holder Stud.
2	—166	Film Trap Gate Holder Stud Screw.
	167	Film Trap gate thimble.
	168	Film Trap Gate Holder Spring.
5	—168½	Film Trap Door Pad.
2	—169	Film Trap Door Trip Lever Screw.
2	—170	Film Trap Door Trip Lever.
2	—170½	Film Trap Door Pad Spring.
2	—171	Film Trap Door Trip Lever Spring.
2 & 5	—172	Projecting Lens Holder.
5	—172½	Projecting Lens Holder Adaptor.
5	—173	Projecting Lens Holder Clamp Screw.
5	—174	Projecting Lens Holder Clamp Screw Handle.
5	—175	P. & S. Lens Holder Clamp Screw.
2	—176	Focusing Slide.
	177	Focusing Slide Gib.
	178	Focusing Slide Gib Pin.
2	—179	Focusing Rack Retain Screw.
3	—180	Focusing Rack Arm.
	181	Focusing Rack Arm & Stereo. Slide Friction Spring.
3	—182	Focusing Pinion Knob (same as stereo.).
3	—183	Focusing Pinion Knob Taper Pin.
3	—184	Focusing Pinion.
	185	Right Front Cover.
	186	Left Front Cover.
	187	Left Front Cover Thumb Screws (2).
	188	Right Back Cover.
	189	Left Back Cover.
	190	Right Cover.
	191	Right Cover Rivets (2).
	192	Right Cover Screw.
	193	Cover Screws (17).
3	—194	Top Plate.
	195	Right Door.
	196	Right Door Hinge.
	197	Right Door Lock Button.
	198	Right Door Lock Spring.
	199	Right Door Lock Stop.
	199½	Right Door Lock Screws (2).
	200	Left Door.
	201	Left Door Hinge.
	202	Left Door Lock Pin.
	203	Left Door Lock Pin Spring.
	204	Left Door Lock Taper Pin.
	205	Right & Left Door Hinge Rivets (11).
	206	Right & Left Door Hinge Screws (11).
	207	Right & Left Door Knobs (2).
	208	Right and Left Door Knob Screws (4).
	209	Shutter Blade one Wing.
	209½	Shutter Blade Stay.
5	—210	Shutter blade screws (3)
3 & 5	—210½	Three Wing Shutter.
	211	Shutter Case.
	212	Shutter Case Cover.
	213	Shutter Case Cover Lock Pins (3).
	214	Shutter Case Support.
	215	Shutter Case Bracket.
	216	Shutter case screws (12)
	216½	Shutter Case Bracket Screws (6).
1	—217½	Stereo. Lens Holder.
	218	Stereo. Lens Holder Clamp Screw.
1	—218½	Stereo. Lens Holder Clamp Ring.
1	—219	Stereo. Clamp Ball.
	220	Stereo Clamp Ball Stud.
	221½	Stereo. Universal Clamp Body.
	222½	Stereo. Universal Clamp.
	223	Stereo. Universal Clamp Pin.
	224	Stereo. Universal Clamp Wing Screw.
1	—225	Stereo. Lens Focus Adjust wing screws (2)
1	—226	Stereo. Lens Adjusting Rod.
1	—227	Stereo. Arm.
1	—228	Stereo. Lens Adjusting Screw.
1	—229	Stereo. Slide.
	230	Stereo. Slide Pin.
	231	Stereo. Focusing Pinion.
1	—232	S. P. Focusing Pinion Knob.
1	—233	S. & P. Focusing Pinion Knob Taper Pin.
	234	Stereo. Slide & Focusing Rack Arm Friction Spring.

The Standard Machine

INSTRUCTIONS* FOR MODEL No. 4

No. 1.—**Removing the Gate.** To remove the gate, loosen screw 525, P 1, and pull gate and spindle off to the right.

No. 2.—Removing Lower Sprocket, Film Chute and Gear. To remove lower sprocket, film chute and gear, drive taper pin out of sprocket 453, P 2. Drive taper pin out of gear 454, P 2, and pull spindle 452, P 2, off to the left. In driving pins use a small steel punch. A heavy hammer is undesirable for such work. A light sharp blow from a small hammer is most effective and least likely to do damage to the parts. Be sure and drive the taper pins the right way.

No. 3.—Removing Film Slide and Cradle. To remove film slide and cradle 437, P 2, loosen screws 501, P 1; screws 526, P 2, and screw 527, P 2, and the parts will come off.

No. 4.—Removing Star and Spindle. To remove star and spindle 401, P 2; bushing 402, P 1, intermittent sprocket 403, P 2, and bushing 404, P 3; first remove film slide and cradle (see Instruction No. 3); then loosen screws 509, P 2, holding cap 497, P 2, and 498, P 3. The parts (star, sprocket, spindle and bushings), may then be lifted out. In replacing same, be sure that the spindle carrying star 401, P 2, is set exactly square with the aperture. This may be accomplished by turning bushings 402, P 1, and 404, P 3, which are eccentric, until the star 401, P 2, hugs the cam 410, P 1, and opposite sprocket teeth are exactly the same distance from lower edges of strips for film slide 438, P 2. This is important since if one side of the intermittent sprocket 403, P 2, is lower than the other, it will necessarily do most of the work of pulling down the film. Another and perhaps better way of leveling sprocket 403, P 2, is to have a thin piece of metal, exactly square on one end and just wide enough to fit snugly in the film track. Slip this down until it touches the sprocket teeth. If it only touches on one side, manipulate bushing 402, P 1, and bushing 404, P 3, until both teeth touch the end of the metal strip. To make this effective, however, the end of the metal strip must be exactly square and it must fit in the film slide snugly. Still a third way of doing this

*See Page 420 for Key.

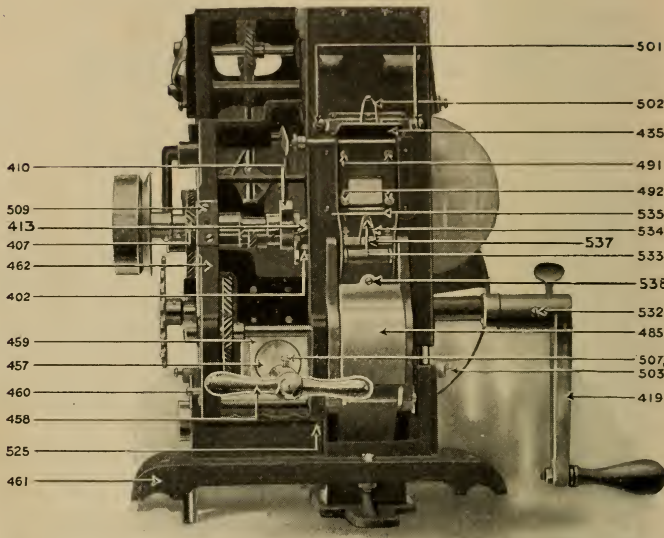


Plate 1.
Fig. 127.

is as follows: On the two bushings will be found a scratch mark running lengthwise on their outer circumference. These scratch marks should be kept parallel or level with each other. These scratch marks may be seen on the inner ends of the two bushings next to the intermittent sprocket.

No. 5.—To Remove Flywheel Spindle. To remove flywheel spindle 405, P 2 and 4, drive taper pin (see Instruction No. 2), out of hub of cam 410, P 1, and loosen screws in collar 409, P 2. Spindle, carrying flywheel, may then be pulled out to the left.

No. 6.—To Remove Cam Pin. Cam pin, 411, P 2, in cam. 410, P 1, may be removed by loosening screw 412, P 2. Pin will then slide out to the left. Tap gently, using a small punch if it sticks.

No. 7.—Removing Cam Shaft Bushings. To remove bronze bearings carrying cam or flywheel shaft, same being located under cap 496 and 497, P 2, proceed as per Instruction No. 5, and then remove steel caps 496 and 497, P 2.

No. 8.—Top Plate and Flap. Top plate and flap, 513, P 3, are removable by taking out six screws holding same.

No. 9.—Removing Upper Sprocket and Spindle. Upper sprocket 443, P 3, may be removed from its spindle by driving out taper pin (see Instruction No. 2), in its hub. Its spindle, 442, P 2, may be removed by first taking off the sprocket, then driving taper pin out of gear 444, P 2. Spindle then slides out to the left.

No. 10.—Removing Upper Sprocket Idler Complete. To remove upper sprocket idler bracket and rollers complete, 448, 449 and 450, P 3, loosen screw holding idler lever 446, P 4, and the whole thing will slide out to the right.

No. 11.—Outside Shutter. Outside shutter may be removed from its shaft by loosening screw 522, P 3.

No. 12.—Shutter Shaft. To remove shaft carrying outside revolving shutter 470, P 4, tap lightly on either side of the shaft with a screwdriver handle, at the same time pulling on the shaft. Do not strike the shaft heavily. Tap lightly while you pull on the shaft.

No. 13.—Outside Shutter Yoke-Holder. To remove yoke-holder for outside shutter casting 464, P 4, loosen screws 500, P 4, and the part will come away.

No. 14.—Shutter Casting. To remove outside shutter casting 463, P 4, follow Instruction No. 13, and then loosen screws 528, P 4. Part will then come away.

No. 15.—Front Plate. Front plate, 529, P 4, may be removed by first following Instructions 13 and 14 and then loosening screws holding plate in place.

No. 16.—Governor. To remove governor lever, 510, P 2, loosen screw 511, P 2, and lever will come off. Governor spindle 427, P 5, may be removed by first taking off the lever and then driving out taper pin holding gear 428, P 5. Next drive straight pin 423, P 5, out of wings 430, P 5. Next drive taper pin out of collar 433, P 5, and spindle may be pulled out downward. Replacing same is a reversal of the above process.

No. 17.—Transmission Spindle. Transmission spindle, 425, P 5, may be removed by driving taper pin out of gear 423, P 5, driving taper pin out of gear 422, P 5, and driving taper pin out of gear 421, P 5.

No. 18.—Driving Shaft. To remove driving shaft, 414, P 5, drive taper pin out of sprocket 415, P 5, and taper pin out of gear 417, P 5. You can then slide the spindle out to the left.

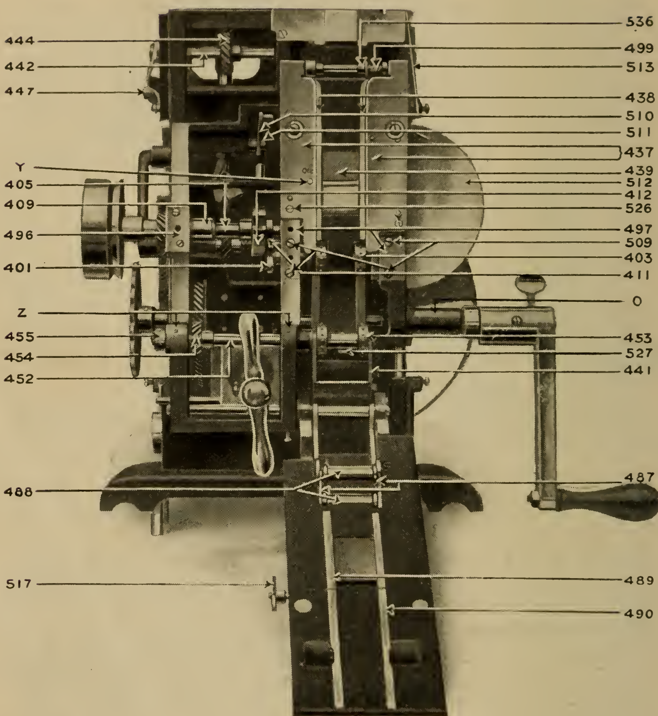


Plate 2.

Fig. 128.

No. 19.—Framing Device Spindle. To remove framing device spindle 456, P 5, take out cotter pin 530, P 5, and pull spindle out, with framing device eccentric 457, P 1, on it. You can then also slip the sliding box 459, P 1, out to the left if you wish.

No. 20.—Outside Shutter Horizontal Shaft. Outside shutter horizontal shaft 469, P 4, may be removed by driving taper pin out of gear 475, P 4. Shaft will then slide out to the left.

No. 21.—Outside Shutter Vertical Gear. Outside shutter vertical gear 474, P 3, may be removed by complying with Instruction No. 20, and then loosening screws 523, P 4, and bronze bearing 471, P 3.

No. 22.—Vertical Shutter Shaft. To remove vertical shaft, 468, P 4, follow Instruction No. 13, then drive taper pin out of gear 475, P 4, and slide shaft out, upward, at the same time sliding gear 472, P 4, off.

No. 23.—Magazine Shoe. Magazine shoe, 465, P 4, is removed by loosening screws 531, P 3.

No. 24.—Tension Strips. Tension strips on gate above tension shoes 489 and 490, P 2, are held in place by screws. Remove the screws and the strips will come off. The bottom end of the tension shoe goes through the metal of the gate and is held by a small pin in either shoe. These shoes may be taken out by removing these small pins.

No. 25.—Idler Bracket Tension Spring. Idler bracket and tension spring 534, P 1, will come off when screw 533, P 1, is removed.

No. 26.—Idler Bracket. Idler bracket, 487, P 2, may be removed by following Instruction No. 25; then pull pin 535, P 1, out and bracket will come away.

No. 27.—Idler Bracket Adjustment. Sprocket idlers, 488, P 2, 450, P 3, and those inside 485, P 1, must be kept set away from the sprockets by about twice the thickness of an ordinary film. If too close it will have a decided tendency to cause the film to run off the sprockets. If too far away, it will allow the film to climb the sprocket teeth; in either event the tendency is to lose the loops, or at least shorten one of them. Adjustment of sprocket idlers is very important and should be carefully looked after by the operator. The lower sprocket idlers which are inside of casing 485, P 1, are adjusted in relation to the sprocket by means of set screw 538, P 1. On the right side of casing 485, P 1, right next to the casting, you will see the end of one of the roller spindles. Adjust screw 538, P 1, until this roller just begins to turn when the machine is run with the

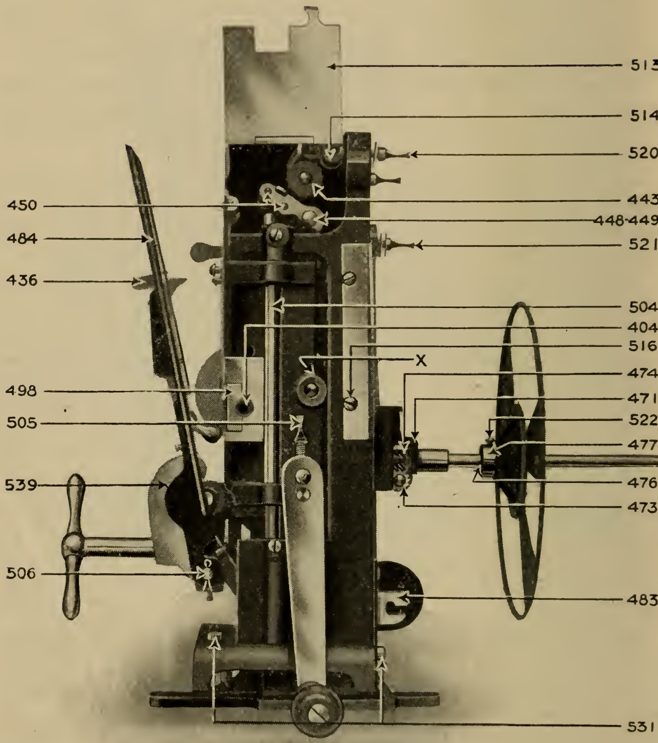


Plate 3.

Fig. 129.

film in, after which set up set screw lock-nut. Upper sprocket 451, P 3, is adjusted by means of a set screw in the bracket just to the left of the roller. By moving this screw in or out the rollers are set closer to or further away from the sprocket. After adjusting be sure and set up the lock-nut so that screw cannot move. Intermittent sprocket idlers 486, P 2, are adjusted in relation to the sprocket by means of set screw 537, P 1. You can tell when this adjustment is properly made as follows: When there is no film in the machine the idler which shows on the front of the gate will remain stationary when the crank is turned. Place a film in the machine and adjust set screw 537, P. 1, until this idler roller just barely begins to turn, after which set up the lock-nut to hold this screw tight.

No. 28.—Adjusting Intermittent Movement. The intermittent sprocket should have just a little circumferential play, but not much. If star 401, P 2, is set up too tight against cam 410, P 1, expansion of the parts, through heat engendered by friction and from the spot, may cause them to bind too much, thus producing undue friction. For this reason there should be just a little play. When this becomes too great through wear, however, the star 401, P 2, must be set up closer to cam 410, P 1. To do this loosen screws 509, P 2, holding caps 497, P 2, and 498, P 3, and give bushing 404, P 3, and bushing 402, P 1, a slight turn in such direction as will raise the intermittent sprocket shaft, or star shaft, thus tightening it against cam 410, P 1. It is important that both bushings be turned the same amount. See Instruction No. 4. When finished, set up screws 509, P 2, tight. Should lost motion develop between bushing 402, P 1, of star spindle 401, P 2, and sprocket 403, P 2, you will find on bushing 402, P 1, a lock-nut and sleeve, 541, P 5; by loosening the lock-nut first you will notice that you can turn the sleeve until all the lost motion disappears; then be sure you tighten the lock-nut as tight as possible, for if the lock-nut is loose while running the machine, it will allow the sleeve to turn and bind up the machine.

No. 29.—Sprocket Teeth. The pull of the film on the teeth of the intermittent sprocket 403, P 2, has the effect of cutting away the metal on one side. This is called "under-cutting." Its effect is to wear the film perforations unduly, which, if of considerable amount, render the picture more or less unsteady. The sprocket may be removed from the shaft and turned end for end, thus presenting the other side of the teeth to the film. To do this the star, spindle and sprocket 401, P 1, should be removed from the machine (see Instruction No.4), and sent by registered

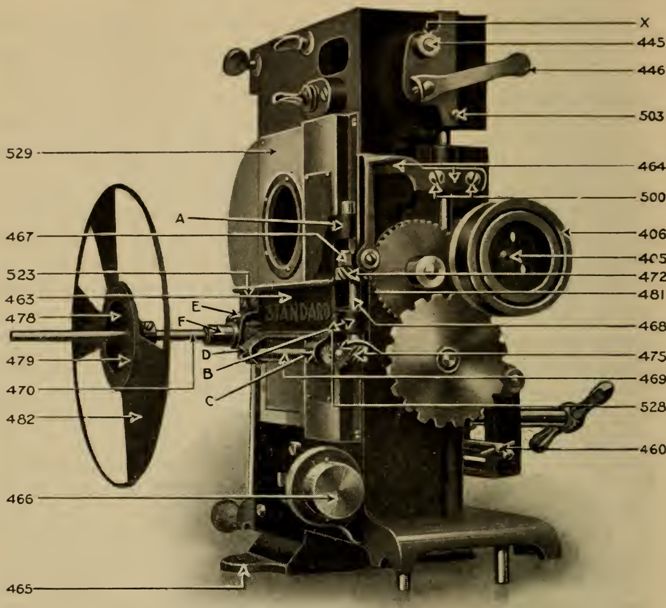


Plate 4.
Fig. 130.

mail to the factory. An extra star, shaft and sprocket should be kept on hand, assembled and ready to put in in place of the old one. When both sides of the teeth are worn a new intermittent sprocket must be installed. It is best to send the part to the factory and have it done right. The cost of mailing is slight, and if an extra star, spindle and sprocket is on hand ready for installation, it is by far the better way.

The teeth of the upper and lower sprockets 443, P 3, and 453, P 2, also wear and may be reversed, (turned end for end) the same as directed for the intermittent, except that the operator can readily perform the operation. Remember, however, that the pin holding same to shaft is tapered, and be careful not to get the large size of the hole in the sprocket hub on the side of the shaft having the smallest size of the hole. Better mark the shaft and sprocket before removing sprocket, so that you will make no mistake. When both sides of teeth are worn a new sprocket may be installed by driving out the pin holding the old one, pulling it from the shaft, slipping new sprocket on and re-inserting the pin. But be sure about having the taper hole right. There is light wear on upper sprocket teeth and lots on the lower; some operators change these sprockets when lower becomes worn.

It does not pay from any point of view to run with badly worn sprocket teeth.

No. 30.—Tension. Tension on the film is a matter of much importance. It should be just sufficient to hold the picture steady. The best test is to set the tension so that the picture will begin to climb up the screen slightly when crank speed increases to about 90 per minute. More than that puts unnecessary strain on the film, intermittent movement of the machine, and in fact the whole mechanism. Tension may be increased or made less by tightening or loosening tension nuts 491 and 492, P 1. The office of the tension springs is to stop the film at the end of the star movement and hold it steady (perfectly still) over the aperture while the picture is exposed. When set tight enough to accomplish this it is sufficient. Some operators try to make the tension springs eliminate jumping of the film caused by worn sprocket teeth or lost motion in the intermittent movement. They may succeed after a fashion, but it is at the expense of excessive wear, both on the machine and film.

No. 31.—Setting Shutter. To adjust outside revolving shutter 482, P 4, turn flywheel 406, P 4, in direction it runs until star barely begins to move. Hold flywheel still with left hand, and, having first loosened screw 522, P 3, turn shutter on spindle, in direction it normally runs until top edge of wide shutter blade covers about half the lens. Tighten screw 522, P 3, slightly, and with a film title threaded in machine, try it with the light. If there are streaks up from the letters of titles, pull top of shutter towards you slightly until streaks disappear. If streaks are downward, pull bottom of shutter towards you. When streaks have entirely disappeared, set up screw 522, P 3, tight.

No. 32.—Shutter Shaft. When inserting shutter shaft, 470, P 4, in bearing 471, P 3, see that arrow on shaft points toward the bearing.

No. 33.—Oil. A motion picture mechanism has heavy work to perform. This is particularly true of the star and cam. It must be adequately lubricated or wear will be excessive. "Adequate lubrication" does not mean flooding the bearings with oil. This does no good, and does do harm. One drop of oil is

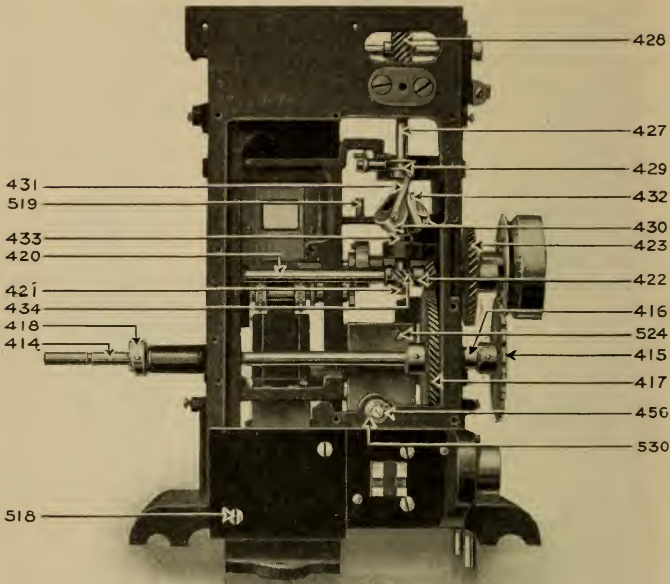


Plate 5.
Fig. 131.

plenty; more simply runs off, gets on the film, or smeared around, making a dirty mess. *The main thing is to use good oil;* use it with reasonable frequency and use but one drop on each bearing. *A good grade of light dynamo oil is best.* Same may be had of any responsible oil dealer. Avoid very thin oils. As a rule they are lacking in lubricating qualities. Many of them are a little better than water. For the chain a good bicycle chain lubricant will be found excellent. It may be had of any dealer in bicycle supplies. Engine valve oil is also excellent. Ordinary lubricating oil may be used, but is not very well suited to such work. Engine valve oil is also excellent for gears. Once a week it is an excellent plan to fill an oil can with gasoline or benzine, and while turning the crank, flood the bearings and gears, thus washing them out clean. A pan should be held under the machine while doing this, and plenty of gasoline should be used.

No. 34.—Framing Carriage. The framing carriage is made to work hard or easy by tightening or loosening sliding box adjustment screw 460, P 1 and P 4.

No. 35.—Oil Holes. Oil holes will be found as follows: Two in top plate of machine; one at X, P 4; one in cap 496, P 2; two in cap 497, P 2; one at Y, P 2; two at Z, P 2; one at O, P 2; one at X, P 3; one at arrow 416, P 5; one behind gear 423, P 5; one at A, P 4; one at B, P 4; one at C, P 4; one at D, P 4; one at E, P 4; one at F, P 4. Besides these the governor bearings, intermittent movement and right-hand intermittent bushing must be oiled; also the sprocket idlers and idlers in film chute.

Bushing No. 413.—On one side of the bushing, No. 413, P 1, carrying end of flywheel spindle 405, P 2 and P 4, will be found a file mark. This file mark indicates the end of the bushing which should be set next to the cam 410, P 1. Be sure and get this bushing in as directed or there will be trouble.

Cleaning Sprockets.—It is of much importance that the various sprockets be kept perfectly clean. Gum or dirt collecting on the face of the intermittent sprocket will cause the film to jump. Gum or dirt collecting on the face of the upper or lower sprocket is likely to cause the film to run off the sprockets or climb the sprocket teeth. Sprocket teeth, particularly the intermittent, should be kept perfectly clean, and an ordinary 10-cent tooth brush is best for the purpose.

Care must be taken that the intermittent sprocket is so set endwise that the edges of the sprockets are equidistant from the inner edges of the plates 437, P 2.

Take-up.—To adjust the tension on take-up, first loosen set screw in lock-nut on end of spindle. To release tension, turn top of lock-nut toward curtain, and opposite for tightening. When the desired results are obtained, tighten set screw in lock-nut to prevent slipping. It is very important that the leather washer between the two metal discs on take-up should be kept thoroughly lubricated at all times. If you permit this to become dry it will stick fast to discs and cause no end of trouble.

Loops.—The upper loop of the film should not be made large enough so that it will touch the top plate when the carriage is framed clear up. The lower loop should not be made too large. Arrange the lower loop so that when the film is locked on the intermittent and lower sprocket the back of the loop will just bear lightly on the metal at the back. This is quite important, and a little practice will enable the operator to get his loops right instead of wrong.

NAMES AND NUMBERS OF PARTS FOR THE STANDARD MECHANISM, MODEL No. 4

Order Parts by Number Only. These Numbers Are the Manufacturer's Regular Stock Numbers. The First Column of Figures Indicates the Plate on Which the Part Is Shown.

2 —401 Star and Spindle (one piece).
1 —402 Bushing for Intermittent Sprocket Spindle (short).
2 —403 Intermittent Sprocket.
3 —404 Bushing for intermittent Sprocket Spindle (long).
2 & 4—405 Fly-wheel Spindle.
4 —406 Fly-wheel.
1 —407 Gear, 14 teeth.
408 Bronze Bearing (Under Cap 496, P. 2).
2 —409 Collar.
1 —410 Cam-wheel.
2 —411 Cam-pin.
2 —412 Screw Holding Cam-pin in place.
1 —413 Bronze Bearing (Upper Bushing, under cap 497, P. 2)
5 —414 Crank-shaft.
415 Chain Sprocket.
5 —416 Collar.
5 —417 Gear, 70 Teeth.
5 —418 Clutch-collar.
1 —419 Crank, Complete.
5 —420 Transmission Spindle.
5 —421 Gear, 15 Teeth.
5 —422 Gear, 12 Teeth.
5 —423 Gear, 42 Teeth.
424 Stereopticon Bracket.
425 Stereopticon Bar.
426 Stereopticon Ring Casting, with Lens Ring.
5 —427 Governor Spindle.
5 —428 Sliding Gear on Governor.
5 —429 Governor Head.
5 —430 Governor Wings.
5 —431 Governor Arms.
5 —432 Governor Pin.
5 —433 Governor Collar.
5 —434 Gear, 8 Teeth.
1 —435 Fire Shutter.
3 —436 Gate Latch.
2 —437 Film Slide and Cradle.
2 —438 Strips for Film-slide (Right and Left).
2 —439 Aperture Plate.
2 —440 Guide Spool for Film-slide.
2 —441 Film Chute.
2 —442 Upper Sprocket Spindle.
3 —443 Upper Sprocket.
2 —444 Gear, 20 Teeth.
4 —445 Collar.
4 —446 Upper Sprocket Idler-roller Lever.
2 —447 Upper Sprocket Idler-roller Spindle.
8 —448 Upper Sprocket Idler-roller Bracket (left).
8 —449 Upper Sprocket Idler-roller Bracket (right).
3 —450 Upper Idler-rollers.
3 —451 Upper Idler (complete) Comprises 446, 447, 448, 449, 450.
2 —452 Lower Sprocket Spindle.
2 —453 Lower Sprocket.
2 —454 Gear, 16 Teeth.
2 —455 Collar.
5 —456 Framing Device Spindle.
1 —457 Framing Device Eccentric.
1 —458 Framing Device Handle.
1 —459 Framing Device Sliding Box.
1 —460 Screw Adjustment for Sliding Box.
1 —461 Large Frame Casting.
1 —462 Sliding Frame Casting.
4 —463 Outside Shutter Casting.
4 —464 Yoke Holder for Outside Shutter Casting.
4 —465 Shoe to Fasten Lower Magazine.
4 —466 Knee to Fasten Idler Arm for Take-up.
4 —467 Yoke for Outside Shutter.
4 —468 Vertical Shaft for Outside Shutter.
4 —469 Horizontal Shaft for Out-Side Shutter.
4 —470 Vertical Shutter Shaft.
3 —471 Bronze Bearing for Outside Shutter.
4 —472 Sliding Gear for Outside Shutter, 14 Teeth.
3 —473 Gear, 12 Teeth, in Mesh With Vertical Gear No. 474 on Outside Shutter.
3 —474 Vertical Gear, 12 Teeth Outside.
4 —475 Gear, 12 Teeth, Outside Shutter (two of these).
3 —476 Bronze Bushing Outside Shutter.
3 —477 Bronze Ring Outside Shutter.
4 —478 Aluminum Flange for Outside Shutter.
4 —479 Aluminum Ring for Outside Shutter.
3 —480 Key for Outside Shutter Bushing No. 476, P.
4 —481 Key for Sliding Outside Shutter Gear 472, P. 4.
4 —482 Aluminum outside Shutter.
8 —483 Stud for Telescope Leg Fastener on 466.
3 —484 Gate Blank.
1 —485 Roller Box on Gate.
2 —487 Idler Bracket (on gate) for Intermittent Sprocket.

2 —488 Rollers on Idler Bracket for Intermittent Sprocket.
2 —489 Tension Strip on Gate (Left and Right).
2 —490 Tension Strip on Gate (Right and Left).
1 —491 Cup for Tension Spring on Gate, Upper Left and Right.
1 —492 Cup for Tension Spring on Gate, Lower Left and Right.
1 —493 Tension Stud, Inside of 491-492.
1 —494 Tension Nut, Part of 491-492.
1 —495 Tension Spring, inside 491 and 492.
2 —496 Cap for Outer Fly-wheel Spindle Bearing.
2 —497 Cap for Intermittent and Fly-wheel Spindle Bearing.
3 —498 Cap for No. 404, Plate 3.
2 —499 Spring for Guiding Spool.
4 —500 Screws for No. 464.
1 —501 Screws for Gate Latch.
1 —502 Spring for Gate Latch.
4 & 1—503 Screws for Sliding Bars.
3 & 4—504 Sliding Bars.
3 —505 Thumb Screw for Crank.
3 —506 Spindle Holding Gate.
1 —507 Screw for Framing Handle.
2 —508 Screw for Cap 496.
1 & 2—509 Screw for 497 and 498.
2 —510 Governor Lever.
2 —511 Screw for Governor Lever.
2 —512 Light Shield.
3 —513 Top Plate and Flap.
3 —514 Rollers in Top Plate.
3 —515 Brackets for Rollers in Top Plate.
3 —516 Screws, (2) Holding Light Shield.
2 —517 Catch for Fire Shutter.
5 —518 Screws to Fasten 465.
5 —519 Stud for Governor Lever.
3 —520 Thumb Screws (2) to Fasten Upper Magazine.
3 —521 Thumb Screw Holding Stereo. Bracket.
3 —522 Screw Holding Outside Shutter to Shaft.
4 —523 Screw Holding 471, P. 3.
5 —524 Screws (2) to fasten Bracket for Sliding Box 459, P. 1.
1 —525 Screw holding Gate Spindle.
2 —526 Screw Holding Film Slide.
2 —527 Screw Holding Film Slide.
4 —528 Screws Holding Outside Shutter Casting 463, P. 4.
4 —529 Front Plate.
5 —530 Cotter Pin for Framing Device Spindle.
3 —531 Screw Holding Shoe to Fasten Lower Magazine.
1 —532 Screw for Driving Handle.
1 —533 Screw to Fasten Tension Spring for Idler Bracket.
1 —534 Tension Spring for Idler Bracket.
1 —535 Pin for Idler Bracket.
2 —536 Guiding Spool Film Slide.
1 —537 Set Screw.
1 —538 Set Screw.
3 —539 Rollers in Roller Box Gate Inside 485, P. 1.
3 —540 Upper Idler Spring.
5 —541 Lock-nut on Intermittent Movement.
542 Stereo Bracket.
543 Stereo Extension Rod.
544 Adjustable arm for take-up
545 Large Chain Sprocket on Adjustable Arm.
546 Small Chain Sprocket on Adjustable Arm.
547 Shaft for Large & Small Chain Sprockets on Adjustable Arm.
548 Short Chain for Take-up.
549 Long Chain for Take-up.
550 Reel Spindle With Collar and Locknut for Take-up.
551 Friction Plate on Lower Reel Spindle.
552 Friction Plate With Chain Sprocket Attached for Take-up Spindle.
553 Friction Washer (leather) for Take-up.
554 Spring (tension) on Take-up Spindle.
555 Eccentric Bushing on Take-up.
556 Tension Spindle on Upper Magazine Complete.
557 Hinges for Magazines.
558 Casting for Upper Magazine.
559 Casting for Lower Magazine.
560 Door Knob on Magazine.

Projection

PROJECTION is a term which, taken as a whole, involves much. To put perfect projection on the screen and maintain it thus requires ability of high order, as well as constant vigilance and some degree of artistic sense. In the first place the light must be distributed over the sheet with perfect evenness, so that there is no shadow, other than that of the photography itself, and no discoloration except that caused by some fault in the film.

To be able to determine accurately, at a glance, whether a faint shadow, or discoloration of the light, is due to the light itself, or to some fault in the film, requires close study and considerable experience. The operator should observe and compare closely. He must study his projection. He must never arrive at the point where he imagines there is nothing more in this connection for him to learn. The high-class operator who produces high-class results can seldom tell you, except in a very general way, what a film portrays, even after he has run it several times. He has his whole attention taken up in constantly watching for faults in the light and in gauging the matter of speed.

When there is doubt as to whether some slight shadow, or discoloration on the screen, is due to the light, or to some fault in the film itself, the matter may be determined by shifting the lamp a very little. If the shadow moves as the arc moves it is the light which is at fault. If the shadow, or discoloration, remains unchanged, it is due to some inherent defect in the film.

Discoloration or shadows due to light fault are detected by observing white, or light colored objects in the picture. A white dress must be pure white all over. If the woman is in the foreground and the bottom of her white skirt is in any degree yellow, the rest being pure white, it means that your light is in need of instant adjustment. Probably the arc is too long. If the discoloration appears elsewhere, it means the same thing, viz: The light requires attention, assuming, of course, that your condensing lenses are of the right focal length. It is not my purpose to tell the operator the separate adjustment to make to overcome or correct every separate fault. He can readily and quickly determine this by experiment. He is supposed to have brains. If he has not a goodly quota of that article he has no right place in an operating room. If he has them, and uses them, he will very quickly learn how to adjust the light to correct the various faults. Ordinarily there is no excuse whatever for any shadow or discoloration of the light on any portion of the screen.

Speed at Which the Film Is Run is a matter deserving of the closest study and attention on the part of the operator. In this is involved one of the finer points of projection. It is this which lifts the real operator out of the class of the ordinary mechanic and makes of him something of an artist. Lack of preception in this matter, or lack of attention to it, stamps the ordinary operator as ordinary, and advertises the fact to the world at large. It lies in the power of the operator to govern absolutely the speed of all moving things on the screen. He cannot change the actor's gesture, or movement, but he can vastly alter its speed, merely by altering the speed of his machine.

The actor may, in fact, bring his fist down on a table as a clincher to an argument, slowly. Run at ordinary speed the fist would come down exactly as the actor's fist did come down. But the actor may have misjudged the action and the operator has it in his power to bring that fist down at the speed to look best and correspond best with the other movements of the subject at that point. He can bring it down with apparently table-splitting force or he can slow the movement until the blow is a gentle tap. In an automobile race he can speed up the machine until the cars seem almost to fly; also he can slow them down until the race is a howling farce. But when it comes to animal or human action he must study each subject closely. He must make the man, woman or animal, as the case may be, act naturally. If the speed is too great the movements are jerky and impossible; if too slow, the other extreme is reached and the figures appear to float along. The operator may not think the possible improvement is great enough to justify close attention to these details. All I can say of the man who takes this view is that he will never, never, in this world, make a high-class operator. It is true that in the ordinary dramatic film the possible improvement in action through speed regulation is not great. Usually the scene is well acted and the camera run at reasonably regular speed. It is nevertheless the fact, however, that there are very few films in which some improvement is not possible, and the man who persistently and consistently bends his entire energy to improving his projection in every possible way is bound to win out sooner or later. Such work cannot but be noticed. It may take time and it may be discouraging, but success will come, and with it, in some degree at least, reward.

In general, aside from the action of separate figures in various scenes, it may be said that as a rule solemn scenes will be improved if the machine turns slowly. Take, for instance, a death bed scene. It is solemn. The figures should move as slowly as is consistent with naturalness. Again, take the Pathe Passion Play; probably the Bible patriarchs in real life actually moved as fast as anyone else. They may have, upon occasion, even run. Nevertheless rapid action does not suit our preconceived notions of such things. I have often seen the Pathe Passion Play run at such enormous speed that the characters were jumping around the screen like a lot of school boys. Such an exhibition was disgusting to the audience and offensive to those of deeply religious inclination and who revere those characters.

Overspeeding the Machine is reprehensible in the extreme. This is an all too common fault and is attributable to managers of theaters who have no respect for the property intrusted to their care by the film exchange, and no adequate conception of the business of exhibiting motion pictures, or their duty to their patrons. The operator is seldom, or never, to blame for this particular outrage—for it is nothing less. A film may be run at the rate of seventy turns of the crank without undue strain, but that speed, if long continued, will seriously injure the projection mechanism. If one will but pause and consider; there are sixteen pictures to each foot of film. Each picture must stop dead still over the aperture and then be displaced by the next one, after exposure. This means that the strip of film between the upper and lower loops must start and stop sixteen times each second, when running at the rate of 60 turns of the crank per minute. If the crank speed be increased to 70 per minute, it means that this stoppage and starting must take place at the rate of 19 per second, instead of 16. If the speed be still further increased to 80 turns of the crank per minute it means that almost 22 pictures will be exposed each second. Not only must the strip of film between the two loops be started, against the considerable pressure of the tension springs, at this terrific speed, but also the intermittent shaft, star and sprocket must be started and stopped at that rate also. It requires slight knowledge or perception to understand the strain placed on the sprocket holes of the light, fragile film, as well as on the geneva movement of the machine. Overspeeding also involves a tighter tension, which still further aggravates the damage. Even with the tight tension, which largely increases the strain on both film and machine, it is seldom that a film will run at high speed without vibration. Sixty feet of film, or, what means the same, sixty turns of the crank per minute, is accounted normal speed. That is the speed at which the camera is supposed to be run in taking the picture. Films and projection machines are calculated to withstand the strain of this speed, and will do so fairly well. However, it is no unusual thing, especially in the nickel houses, also sometimes in theaters of the better class, to see a 900-foot film run through in ten minutes, which means 90 feet per minute, or a geneva speed of 24 per second. Such speed is an outrage upon the exchange owning the film, upon the projection mechanism, and upon the audience, since the action on the screen becomes merely a series of jumping-jack antics.

Managers seek to excuse this practice on two grounds, viz: "There is a crowd waiting to get in and we must rush 'em through and get the money," and, "My patrons demand a certain number of pictures and I cannot run that number at the right speed and make a living." Neither of these excuses is good. The first one is no excuse at all. The manager making it simply admits his willingness to swindle the patrons who have already paid admission in order to get the money of those who are waiting. The second excuse is puerile, since it is the managers themselves who have educated their patrons to expect more than can be profitably supplied. Managers, instead of working together, have, in a senseless endeavor to best each other, increased their programmes beyond all reasonable limits. But, aside from this, I do not believe the audience exists that would not prefer to see three reels properly projected, than four or five run through at break-neck speed. Managers claim this is not the fact, but I flatly dispute them. The fact is that they are afraid to try the matter out, putting on first-class projection at proper speed.

But this is not all of the story of wrong. The manager who compels this running at high speed injures the film. The sprocket holes are strained and weakened. Every manager who receives that film thereafter must suffer from the work of the speed maniac. He has injured the show in perhaps fifty other houses that must use that film thereafter, and he has lessened the enjoyment of perhaps 75,000 people who will afterward see that film as a part of an exhibition they have paid money to see. Exchanges certainly ought to take drastic measures to put a stop to overspeeding, and overspeeding may be defined as anything less than 15 minutes for a 1,000-foot reel, or 13 minutes for a 900-foot reel.

THE FILM

The film is a strip of celluloid 1⅜ inches wide by from 5½ to 6 one-thousandths of an inch in thickness, on which is printed a series of snap shot photographs, taken at the rate of approximately 16 per second. There are 16 pictures to each foot of film, each picture occupying a space three-fourths of an inch by one inch. Along either edge are perforations at the rate of 64 to the foot, or four to each picture. The photographic emulsion is itself about 1-1,000 of an inch in thickness, which must be deducted from the film thickness above given to secure the actual celluloid measurement.

Strictly speaking there is no such thing as a moving picture. What is termed a moving picture is an optical illusion due to an extremely rapid succession of photographic views of moving objects, one being blended into the next, through what is termed the "persistence of vision," producing the impression of continuous movement. It must be remembered, in this connection, that when one views the projection of a film one looks at and actually sees every one of 16 separate photographs every time the crank of the machine revolves. This means, at normal speed, about 1,000 photographs per minute. In viewing 1,000 feet of film the eye has looked at 16,000 separate and distinct photographs, any one of which could be enlarged and placed in a frame to decorate the wall of your home or office.

In projection, the photographic magnification is tremendous. The aperture of the machine is approximately 11-16ths by 15-16ths of an inch in size. In use it is covered by a photograph which is often magnified to a picture 15 by 20 feet in size, or even larger. This means that a picture 20 feet wide is magnified more than 40,000 times. That is to say it occupies on the screen more than 40,000 times the area it does at the aperture of the machine. When it is remembered that every defect in photography will be magnified in exactly the same proportion, the marvels of photography stand revealed. It is worthy of thought that every one of millions of blades of grass, leaves on trees, and numberless other objects can be definitely impressed on an emulsion 11-16 by 15-16 of an inch in area, at the rate of sixteen times per second, and reproduced at even more than life size, every blade of grass, every leaf and every other object, practically perfect. A whole locomotive and train of cars is compressed into that comparatively infinitesimal space and then again reproduced life size. Truly it is marvelous. Such thoughts cannot but tend to give the operator an added respect for his profession.

Naturally an article so thin and delicate as a film is readily susceptible to damage. It is easily torn in two or scratched, especially the emulsion. Unless of the non-inflammable type, it ignites very quickly and burns fiercely. In burning it furnishes its own oxygen, hence it is almost impossible to smother a fire fed by film. Ordinary wheat flour is about the only substance which will smother out a film fire. You cannot do it by closing a metal box. You cannot do it with sand, though the flames may be kept down by its use.

Fully nine-tenths of the damage to film comes from the process known as "pulling down" in rewinding. This consists in holding one reel stationary while the other is revolved. The evils of the process have been fully set forth under the heading "Rewinders and Rewinding," page 372.

There is now a tendency to make reels twelve and fourteen inches in diameter, instead of ten as in the past. This is good. The manufacturers have been turning out subjects either 1,000 feet in length, or of such length that two of them (generally known as a "split reel") make between 900 and 1,000 feet. Now 900 feet of film of ordinary thickness is all that a ten-inch reel will comfortably hold. If the film stock happens to be just a trifle thicker than usual, 1,000 feet is more than a ten-inch reel can accommodate. This overloading of reels has been a source of great annoyance to operators. The new, larger reel may or may not help this condition, according to whether exchanges proceed to overload them just as badly as they do the ten-inch reel. The evils of the overloaded reel are threefold. That portion of the film outside the reel sides is unprotected and liable to damage in several ways. The portion of the film above the rim of the reel is always likely to, and often does, slip off, to the annoyance of the operator, who has to wind it on again, as well as the possible damage to the film from being smeared over a dirty or at least a dusty floor. But the greatest damage comes from the temptation to pull the film down as tightly as possible in order to get it all wound down inside the reel. Then, too, the overloaded reel usually rubs on the sides of the magazine, seriously interfering with take-up operation and requiring a very tight tension on same, if the take-up is to be made to do its duty all through to the end of the reel.

As a matter of fact no film should fill a reel to within more than a quarter inch of the edge. That is to say, when a film is all wound on the reel, not too tightly, it should still lack that much of being full. The whole film is then properly protected from damage by the metal sides of the reel.

However, the large size reel will serve one good purpose, from the operators' point of view; it will allow of the use of 1,500 foot subjects (without overloading), and will do away with reels overloaded by 1,000 feet. This will mean less bother and labor for the operator, also it will have one evil effect, viz: It will require a still tighter take-up tension, which is very bad indeed.

A Leader and Opaque Tailpiece on all films is essential for several reasons. In the first place the leader protects the title. In threading into the take-up it is frequently desirable, if not necessary, to fold an inch or so of the end of the film over on itself. By so doing it is made stiffer and is more easily thrust under the reel-spring. This means that the leader will occasionally break where it is folded, hence there will be gradual wasting away. If this occurs on the title the damage is quite evident. Soon there will have to be a new title provided. If, however, it is only a leader that is being thus damaged, it is not serious. But there is another reason why leaders should be used, viz: In rewinding, when the job is done, the end of the film usually flaps around anywhere from one to a dozen times before the reel stops revolving, and if there be no leader to receive the brunt of this rough treatment, the title is injured. There is yet another reason which not only deals with the necessity for leaders, but also with their length. About 30 inches of film is required to thread into the take-up. If there be not enough leader, the title will be practically all on the take-up side of the machine aperture when threading is completed. In order that the run may commence with the first image of the title it is necessary that there be not less than 30 inches of leader. If the title be short, even this is not sufficient. If a short title comes on the instant the machine starts it will be gone before the operator can frame up and adjust his light, unless the film be threaded in frame on the first title picture, or the leader be a blank which has been exposed in the printing machine and developed, thus leaving only the dividing lines, which may be used as a guide in framing.

As a matter of fact, leaders should be of exposed film, developed very dense, and should be full four feet in length. This would give the operator time to frame up, adjust his light and have everything just right when the title comes on. Under these conditions if the machine be run slowly at the start the title would have to be very short indeed if the audience could not read it. As a substitute many houses show a stereopticon title slide before running the reel. I do not fancy this scheme. It savors of a makeshift. If things are as they should be there will be no necessity for a slide title, but in many cases it is unavoidable, and therefore better than nothing.

I strongly advise managers to insist on leaders not less than 48 inches in length on all films; also that they be, if possible, of the kind showing dividing lines. If exchanges will not supply such leaders it will pay theater managers to buy blank film and use leaders of their own.

It is important that there be a tail-piece on every film. It need not exceed 12 inches in length, but it should by all means be there and should be of the opaque variety. When the light is shut off by the tail-piece the machine should be instantly stopped. Many operators have a most reprehensible habit of running the machine until the end of the film has passed over the aperture and the white light is on the screen. This instantly destroys all the illusion. It is in the nature of a most unpleasant shock, particularly if the audience be deeply interested in the picture.

Stop your machine while the tail-piece is over the aperture. If there be no tail-piece, stop the machine when the end of the film comes out of the upper magazine, before it has gotten past the aperture. Never, under any circumstances, allow white light to show on the screen. Such work is crude in the extreme.

Injury to the film in passing through the modern motion picture mechanism is invariably due to either the bad condition of the film itself, or to the laziness, carelessness or lack of knowledge of the operator, or to the false economy of managers who refuse necessary repairs to the machine.

It is an unfortunate fact that exchanges still fail to give films proper inspection, and to make necessary repairs, though there has been considerable improvement in this respect of late. An exchange inspector, as a rule, makes the most superficial sort of inspection. Patches by him or her are poorly made, while loose patches are given no attention at all. Split sprocket holes are seldom notched—in fact the inspection is usually very far from being complete. In justice it must be said that the General Film Company is working improvement in this respect.

Many times reels are received too late for any but the most hasty inspection, or none at all, even by the operator himself. Naturally there is likely to be trouble and damage to the films. It is probable there will be loose patches which will catch on the sprocket idlers, tearing the film in two and probably splitting it for a foot or more. Patches in which sprocket holes are not properly matched will climb the sprocket teeth, causing the loss of a loop, or will grip the teeth of the sprocket and wrap around it. Split sprocket holes will catch on an idler and a section of the edge of the film will be split off, if nothing worse.

Given a properly adjusted machine, with sprockets in good condition, and a film properly inspected and repaired, all this could be avoided. The writer has often made the assertion that he can run a film through a modern projection mechanism one thousand times and have not one single mark on it, that can be seen on the screen, except for the scratches caused by the take-up tension, which cannot be avoided until such time as some practical, feasible method of equalizing take-up tension be found. The above, however, is based on the supposition that he be given time to do the rewinding properly, or be supplied with a motor rewind fixed up along the lines suggested under "Rewinding."

The underlying cause of such poor inspection of films is, I believe, the endeavor on the part of the exchanges to get too much work out of a film, as well as an unwillingness to expend the proper amount of money on inspection. But the exhibitor is himself partly to blame. Often he demands a certain film, utterly regardless of whether or not there is time to give it proper inspection and repairs. Many times an exhibitor who is in a hurry for his reels will demand that they be given him without waiting for any inspection at all. This is decidedly wrong. It is neither fair to himself, his audience, nor the exchange. There may be some slight fault in the film which will cause heavy damage unless it is repaired. Then, too, the exhibitor who takes his films without inspection will heartily upbraid the exchange if the film is in bad condition; also he will most likely blame his operator if a break occurs and the show is stopped. When a film leaves the exchange in anything but the best possible condition a wrong is done all around. If present prices will not admit of keeping the films in first-class condition, then it is high time that they be raised.

I am well aware that the question of inspection and repairs presents a problem with many angles, not at all easy to adjust. However, this I can say without fear of successful contradiction, there is absolutely no excuse whatever for the utterly miserable condition in which many films are received by the operator. I have seen films sent out by exchanges in a condition that was nothing less than outrageous. For the good of the business as a whole some method of stopping such things should be found.

Another condition responsible for immense damage is the fact that some, though not all, new film has a tendency to wind on the reel in octagon shape. This means that unless very heavy tension indeed be used on the take-up, with consequent heavy damage to at least the first hundred feet or so of the film, it will occupy a much greater space when rewound than it did before; also in rewinding it will have the same tendency to coil in octagon form, and will do so unless there be heavy tension on the reel—more than is possible when rewinding by hand—or the roll be "pulled down" several times in the process of rewinding, and pulled down hard, too. Think a moment. The emulsion is soft on new, first run film. What will happen to it if pulled down hard—or pulled down at all, for that matter? A new film which has the tendency to rewind in octagon shape should not be placed on a reel which it anywhere nearly fills full when wound tightly.

On first-run films the emulsion, as has been said, is soft. It has a very decided tendency to deposit on the tension springs, or shoes. Often when running first-run films, it is necessary to stop and clean the tension springs, or shoes several times. The deposit of emulsion is usually made manifest by a more or less loud clattering, or jerking of the springs, or shoes. It sometimes becomes very bad indeed before the reel is all run. If the springs, or shoes, are not cleaned the deposit will continue until it will stop, or may cut or tear the film. At any rate it will scratch and roughen the stock between the sprocket holes. To remove the emulsion deposit use either a wet rag, a silver coin, or some soft metal.

Never use a screw-driver or knife blade to remove emulsion from tension springs, or shoes.

By so doing you will most likely scratch and roughen the polished surface, thus making a bad matter much worse. There is nothing which will prevent the deposit of emulsion on the tension springs, or shoes, but it may be lessened by carrying as light a tension as possible and rubbing ordinary tallow on the springs, or shoes, before threading. A piece of tallow candle is excellent for the purpose.

Film should be kept near the floor in an operating room, since it is much warmer near the ceiling. It should be kept in a metal box having compartments for each reel, and one compartment below to hold a wet sponge or water. The film should be treated with a little glycerine once in a while, but this is only accomplished by having the film in actual contact with the liquid, as per directions further on. The glycerine is for the purpose of keeping the film soft and pliable, which it does by reason of the fact that it has the property of rapidly absorbing moisture.

Should water, by any accident, be spilled over a reel of film, or it even be dropped in a pail of water, it may be saved from damage if unrolled very quickly, not allowing the emulsion, which will be quickly softened, to touch anything. But the unrolling must be done very quickly or the emulsion will stick to the back of the film and pull off. This does not apply to colored or tinted film, though even these may sometimes be saved by very prompt action. The writer once rescued a first-run film from destruction thus: He happened to be in the operating room after the show had closed for the night. In taking the last reel from the magazine it slipped from the operator's hands and landed in a pail of water, being practically submerged. He grabbed the reel, ran down stairs, handed the end to an usher, who ran to the front end of the theater, looped the film over a chairback, ran back and forth until the whole film lay across the back of the seats. The emulsion became very soft in places, but next morning it was found that a total of less than ten feet was damaged. The exchange people never knew of the occurrence until more than a month after, when they were told of it.

Mending the Film, i. e., making patches in it, is a matter which is of the utmost importance. Badly made patches are the cause of unending annoyance, as well as immense damage to the film itself.

If the patch be made in such manner that the sprocket holes do not match perfectly there is likely to be a jump of the picture on the screen as the patch goes over the intermittent sprocket teeth, due to the fact that the hole is too small to allow of the sprocket tooth setting properly therein. There is also the liability of (a) the hole locking on the upper sprocket tooth and pulling the loop around under the sprocket. (b) The film running off the sprocket. (c) The intermittent sprocket climing one or more holes, thus shortening one of the loops, making the other proportionately longer and throwing the picture out of frame. (d) The take-up tension pulling the film over the lower sprocket, thus losing the lower loop. All this is liable to occur also where one of the holes is properly matched, but the other is not, thus making one hole small and making the film, as a whole, crooked at that point. You will see, therefore, the importance of matching the sprocket holes perfectly.

In the operating room it is customary to make patches with the fingers. Film cement welds more than it glues the film together. Considerable pressure is, therefore, necessary to make a perfect joint; much more than can be given by the fingers alone. Also with the fingers the pressure cannot possibly be applied evenly. Until recently there has been no film mender suitable for use in the operating room.

To Make a Patch cut the film, as shown in Fig. 133, leaving a stub as shown at A. This stub should be not less than ⅛-inch

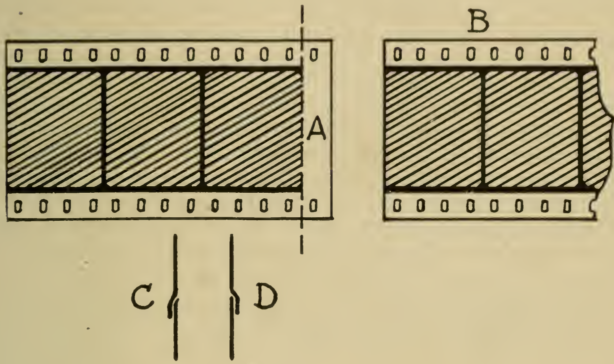


Fig. 133.

and not more than 3-16 of an inch in length. The latter measurement is best, as it will be found difficult for the operator, usually working in a hurry, to make a good patch only ⅛ inch wide; but if wider than 3-16 the patch will be stiff. End B should be cut exactly on the dividing line between two pictures. Scrape every particle of emulsion off stub end A, and scrape back for ⅛-inch on celluloid side of end B; also roughen the emulsion and remove all dirt and grease. A very sharp knife is best to scrape with. Some use the blade of a safety razor. Be sure to thoroughly scrape end B and to scrape every particle of the emulsion off stub end, A. Cement will not stick to emulsion. You must remember that the emulsion covers the entire film on one side, therefore be careful to get it all off around the sprocket holes. This is where many make their error in patching film. They scrape the center of the stub and the center of the back of end B, but do not scrape thoroughly around the sprocket holes, where the greatest strain will come. In consequence their patches soon come loose around the sprocket holes and there is trouble. The stub should be scraped to a straight line, as per dotted line, else there will be a flash of white light on the screen as the patch passes. It is advisable to make the joint in such a manner that the ends will come together as at C, Fig. 133, not as at D. If made as at D, there is greater danger of a loose end catching a sprocket idler, though this does not always hold true, the film passing over one of the sprockets of some machines the other way.

Having scraped the ends clean as directed, place them together so that the sprocket holes exactly match (if patch is to be made with fingers), with the emulsion side of both ends either up or down—that is to say, on the same side. Grasp one edge firmly with thumb and finger and apply cement, with the cement bottle brush, to the other. Clamp the cemented edge down tightly, being careful the sprocket holes exactly match, with thumb and finger of other hand, releasing opposite edge. Apply cement to other edge and clamp that also, applying all the pressure you can for about five seconds or so, and the patch is done. Every cement bottle should have a small brush attached to the under side of its cork. When you buy cement accept none without the brush. It is put up that way now by many, and should be by all.

Film Cement may be easily made. There are many formulas, but the following is perhaps as good as any for both inflammable and non-inflammable stock; ½ pound of acetic ether, ¼ pound of acetone merch, in which dissolve six feet of non-inflammable film from which the emulsion has been removed.

For inflammable film, a piece of film three inches long dissolved in one ounce of acetic ether is a satisfactory cement, but it will not work on N. I. (non-inflammable) stock. In dissolving the film, in either case, first remove the emulsion and then cut the film in fine strips.

Emulsion May Be Removed Entirely From Film by soaking it in warm water, to which ordinary washing soda has been added. Put in plenty of soda. Wash the film afterwards in clean, warm water.

Moistening Dry Film.—Traveling exhibitors often find that a reel which has been a long time in use has become very dry and brittle. It may be re-moistened and rendered pliable by unwinding into a large, metal can, in the bottom of which water has been placed, with a wire screen over it to keep the film from contact therewith. Cover tightly, set in a moderately warm place until the film is soft and pliable. Watch closely, however, since if made too moist the emulsion will stick to the back of the film when it is rewound.

It is even possible to give a film a glycerine bath, as follows: In a long, shallow pan place a solution of 30 parts of clear water to one part of glycerine. Make a drum of two barrel heads and slats. Attach the reel containing the film to one end of the pan and by revolving the drum draw the film very slowly through the liquid, winding on the drum with the emulsion side out. After the film is all on the drum, revolve it rapidly to throw off the surplus liquid, then continue to revolve the drum slowly until the film is dry. It should not be used for two or three days. Perform this operation in a room entirely free from dust, or you will spoil your film.

Due to lack of proper inspection it is usually advisable, where practical, to inspect the films at the theater before they are run. To do this place the reel on rewinder, and rewind it very slowly, holding the edges between the thumb and forefinger with pressure enough to cup it slightly. By so doing you instantly detect all stiff or loose patches. Cut out the stiff ones and remake. Cement all loose patches and notch all split sprocket holes. If more than two sprocket holes are missing on one side—that is, in succession, of course—cut the film and make a patch. Inspection pays, and an ounce of prevention is worth a pound of cure. Managers, however, should not expect operators to inspect films for nothing. Such work is no part of an operator's duty and should by all means be paid for, aside from the operator's regular salary.

A Film May Be Measured by running it through the machine, counting the turns of the crank. All American machines, except the Viascope, pass exactly the same amount; one foot to every turn of the crank, or about 60 ft. a minute.

KEYSTONE EFFECT

Where the machine sets high above the screen, the bottom of the picture is wider than its top, thus producing what we term a "keystone effect." This is due to the fact that under these conditions it is a greater distance from the bottom of the screen to the lens, than it is from the top of the screen to the lens; as indicated by Fig. 134, in which A is the lens, B C the screen, and E F the floor line. Dotted line B D C represents the curtain in the position it would have to be in order to be square with the lens. By this diagram we readily see that the distance from lens A to screen B C is greater at C than it is at B, by the distance D C. Knowing that the light rays spread as they travel, it of course naturally follows that they will spread a greater distance at the bottom of the screen, under these conditions, than they will at the top, with the result that the bottom of the picture will be wider than its top, as illustrated at H.

The same proposition confronts us when the screen is set to one side of the auditorium, except that under these conditions the keystone effect will be sidewise instead of up and down; that is to say, the picture will be wider on one side than on the other. The keystone effect may be overcome by filling in a portion of the aperture with solder and filing it until the edges of the picture on the screen are parallel. When the machine sets above the screen so that the effect is up and down, then it is necessary to fill in with solder on either side of the aperture, making the aperture narrower at the top than at the bottom. The best, and in fact the only practical way to do this is to fill in with solder and file the aperture to shape while the light is on, but first remove one of condensing lenses so that the spot will be very large, as otherwise it would be too hot to work in. By this method you can see exactly the effect of every stroke of the file. Be very careful that you do not get a little too much off, because then you will have the whole job to do over again.

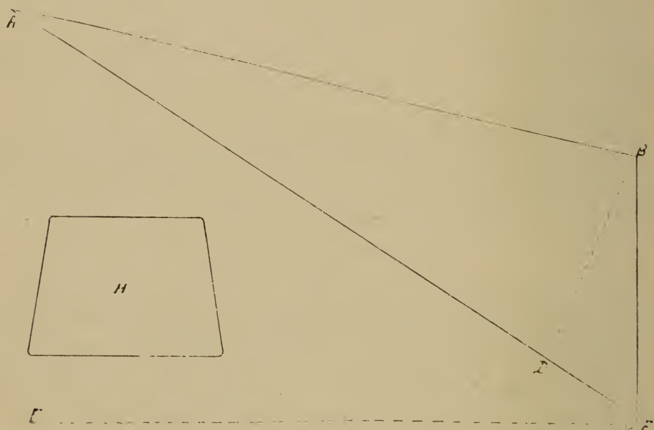


Fig. 134.

If the effect is sidewise, then it is the top and bottom aperture that must be filled in and filed until the top and bottom of the picture are parallel. The keystone effect is usually accompanied by an out-of-focus effect also, due to exactly the same cause. It is claimed that the focus can be made perfect under the following conditions; by loosening the aperture plate and slipping a narrow piece of tin under it, allowing it to rest close to the lower screws, thus tilting the plate slightly. I have not had the opportunity to make a practical test of this scheme, but it sounds reasonable, and I believe it will work out all right. At least it is worth a trial.

AMPERAGE

There is a considerable difference of opinion as to the amount of current that should be used under varying conditions; a large misunderstanding of the whole proposition and a wide lack of the application of good common sense in the matter of amperage. There is, as a general thing, no disposition to seek out whys and wherefores, but rather an inclination to blunder along by rule o' thumb. I have talked with managers who, after expending from five to fifteen minutes explaining how thoroughly they knew everything knowable about theater management, gravely proceeded to expound the following: "Of course we have to use a heavy amperage on this long throw."

First and foremost let me explain that, within reasonable limits of course, say up to anyhow 150 feet, added length of throw has little or nothing to do with the matter of additional light requirement. You can project exactly as brilliant a picture with say 30 amperes at 100 feet as you can at 50, provided the *size* be the same in each case. This holds true unless the air be very dusty or very smoky. There is practically no loss of light whatever in traversing the air for any distance ordinarily used for projection.

The average man will deny this, citing, in proof, the fact that the brilliancy of an ordinary light diminishes inversely in proportion to the distance. He simply makes the error of reciting a rule applicable only to an open light, from which light rays travel in every direction. The action of such a light is shown in Fig. 134A. Since the rays travel in straight lines it follows that they spread out as they travel. This spreading weakens the illumination; in fact, it diminishes in inverse proportion to the square of the distance.

This does not, however, hold good with projection light. Here we have an entirely different proposition, since, instead of traveling in every direction, the rays are restricted to a certain, given area, and every ray passing through the projection lens, and, not diverted in course of passage through the air by a particle of dust or other impurity, must reach the screen and strike its surface within a certain prescribed space. There is some slight loss between the film and the projection lens, but due to concentration of light by the condensers, it seems to be very slight, and to be about the same regardless of distance of lens from the film, provided condensers of proper focal length be used.

To pursue the matter somewhat further, and get at the real meat of the subject: Suppose we have a lens projecting a picture 8 x 10 feet at 60 feet. In a space 8 x 10 there are 80 square feet of surface. Now, while light rays are really numberless, let us suppose, for the purpose of illustration, that we have exactly 160 rays of light passing through the projection lens. That would, of course, mean that each square foot of screen would be illuminated by just two rays of light. Now suppose that we change our lens to one projecting picture 12 x 16, having 192 square feet of surface. The light remains the same. The surface has been more than doubled. Therefore it follows that the light, being spread over more than twice the area, has been weakened, so far as screen illumination be concerned, by more than one-half.

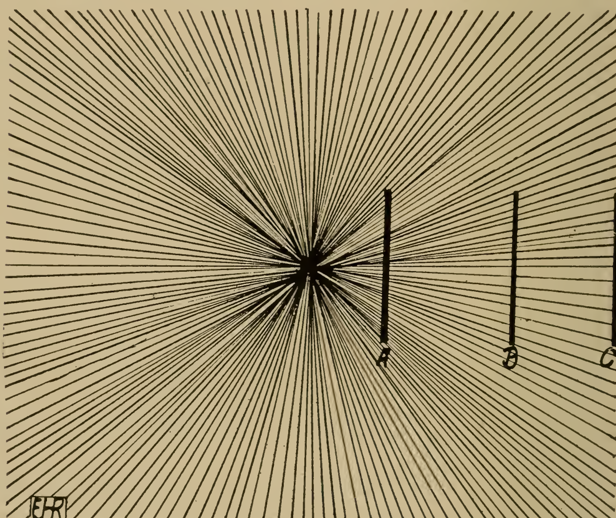


Fig. 134A.

Where we formerly had two rays for every square foot of screen surface, we now have less than one ray to the square foot. We still have the same total amount of light, but we have, in a limited degree, invoked the law spoken of in the first place.

We have thus learned that the illumination decreases as the area over which it is spread is increased. It, therefore, naturally follows that if you have an illuminant of a certain given intensity, the light from which is being spread over a certain given surface, say, for instance, an area of 100 square feet, and this area is increased to, let us assume, 200 square feet, the strength of the illumination must be increased in such proportion as will supply to each square foot of the increased area an amount of light equal to that formerly projected to each square foot of the screen of smaller area.

The following table will be found quite satisfactory for use with any good non-reflecting screen, such as plaster wall, white muslin, etc. For such screens, provided they be in good condition, it will serve every purpose, except that for A. C. the amperage should go above 60 on large pictures, using carbons larger than 5/8, of course. For a picture 15 x 20, not less than 80 amperes should be used. I have made 60 the limit in the table for the simple reason that all operating transformers have a maximum output of 60 amperes.

TABLE VI.

Picture.	Area Sq. Ft.	Amperes D. C.	Amperes A. C.
6.75 x 9	48	20	35
7.5 x 10	75	20	35
8.25 x 11	91	20	35
9 x 12	108	22	35
9.75 x 13	127	25	38
10.5 x 14	147	29	44
11.25 x 15	169	33	50
12 x 16	192	38	58
12.75 x 17	216	43	60
13.5 x 18	243	45	60
14.25 x 19	268	45	60
15 x 20	300	45	60

It will, of course, be understood that if a type of reflecting, or semi-reflecting screen be used, the above figures may be diminished by probably 25 per cent.; possibly even more than that with the mirror screen, but with this proviso: Never go under 20 amperes D. C. or 30 amperes A. C.; except for a picture less than 9 feet (when only one picture dimension is given the width is always meant), no matter what kind of screen you may have.

We have learned by this that the screen brilliancy will depend not upon the total amount of light projected to its surface, but on the total amount of light projected to each square foot of its surface. This naturally brings us to the inevitable conclusion that:

A certain given amperage per square foot of screen will give a certain definite illumination to the screen (other things being equal.)

There are so many different equations entering into this proposition that no set rule can be given which will apply to all cases. The curtain brilliancy will depend not only on the amperage per square foot of screen, but also upon the set of the carbons, and the kind, and size of carbon used; upon the kind of screen used; upon the condition of the atmosphere; upon the kind and amount of auditorium lighting; and upon the density of the films. With a properly proportioned optical system—that is to say, with condensers of proper focal length to fit the objective lens—the length of the throw has very little bearing or effect on the screen illumination.

THE SCREEN

The screen is one factor deserving close study and careful consideration by every operator and manager, since it is what receives the picture and upon it much depends. It is not the purpose of this work to make comparisons between the various patent screens on the market, or between them and the ordinary curtains of plaster. cloth, etc., further than to point out the approximate effect of each.

The Plaster Screen is excellent. It produces as artistic a result as any surface to be had except plain white muslin. It should, however, be finished smooth and perfectly flat, using nothing but plaster of paris for the last coat. The finishing coat must be heavy enough so that the darker plaster beneath will be thoroughly and completely covered. The plaster screen may be and should be coated with either white Alabastine. or its equivalent, to which a little blue has been added, or with English whiting mixed with water in which a handful of glue has been dissolved, and to which just a little ultramarine blue has been added. Get dry blue and "break it up" by adding just a little water at a time, while stirring continuously, before adding to the coating. This coating should be washed off at least once a month, and a new one put on. It may not look dingy, but you would discover, if you coated half of it and left the old coating on the other half, there would be a surprising difference.

White, bleached muslin, such as is used for bedsheets, of good quality, makes an excellent screen; though there is much light loss, since a great deal of it goes through the cloth. Two of them should be made and the one in use be taken down every two weeks and laundered. The muslin may be had as wide as 108 inches. A picture projected on perfectly white cloth has a soft tone not found with the use of any other screen, but it requires a greater amperage to produce a given curtain brilliancy than with plaster, and much greater than with a reflecting screen. Metal, asbestos, etc., should not be used for a curtain. If cloth is not available, and you do not wish to invest in one of the patent screens, it would be better to put up a plaster curtain.

The Mirror Screen is nothing more or less than a huge plate glass mirror, having its front surface thoroughly ground, or frosted. The advantage of this type of screen lies in the fact that a given curtain brilliancy can be had with very much less current consumption. This renders it of especial value where A. C. is used. The screens are boxed in a solid wooden frame, backed by felt and lumber so that there is practically no danger of breakage. These screens can be made in any size up to 13½ x 18½ feet. They weigh approximately 10 pounds per square foot, including the frame.

Every mirror screen should be puttied around the edges of the face (using plenty of putty), beveling it from the frame to the glass so as to make a water-shed all around the edge of the glass, the same as a window light is put into a window frame. Examine every time the screen is washed to see that it is water-tight. A mirror of any kind that becomes very damp or wet will spoil.

The mirror screen can be cleaned by scrubbing with soap and water to which may be added a very small amount of the finest pumice, or whiting, and *while it is still wet,* rinse with clear water, flushing it freely, and letting it dry without touching it. To keep the water from running on the stage, place a galvanized trough fitted to the bottom of the frame with enough drain to run the water into a bucket or pan, or a pipe to the outside. Where the trough is joined to the frame, putty or asphaltum can be applied to the joint, thereby making it water-proof. It is also a very good plan to paint the bottom of the frame and the putty, up to the glass, with pure asphaltum paint.

Aluminum Screens to be effective must have some scheme of rather dull, matte finish. A polished aluminum screen is not good. It will reflect the light in such a manner that there is the appearance of a haze before the picture; also there will be a metallic coldness to it. I am informed that the "Sunlight" Screen produces an excellent effect, but have not had the opportunity afforded of witnessing its performance, therefore cannot give it my approval. The value of such a screen, as in the case of the mirror screen, lies in the fact that less current consumption is necessary to produce a given curtain brilliancy. Aluminum paints I cannot recommend. It is possible to apply them in such manner as to obtain fairly good results, but the final outcome is always problematical, with large chances that it will not be satisfactory. A good home-made curtain paint is prepared as follows: Get some good white lead; mix it flat—i. e., with about two-thirds turpentine and one-third boiled linseed oil. Add enough ultramarine blue, ground in oil, to cause the paint to assume a very light blue tint when in the pail. Apply two or three reasonably thin coats, rather than one heavy one, being very careful not to leave any brush marks.

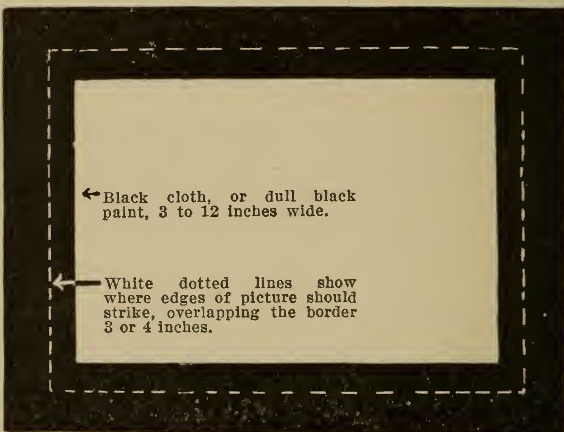


Fig. 134B.

When the screen is used for motion pictures only, it should be outlined with dull black, allowing the same to extend in so that the light will lap over on it for two to three inches, as per Fig. 134B. Adjust your light on the screen exactly as you want it to be, and, with a straight-edge, while the light is on, draw lines about two to three inches inside its edge all around to serve as a guide in applying the black. Instead of paint, a dull black cloth is excellent, but it should be fastened down flat on the screen. But whether paint or cloth be used, it should be carefully borne in mind that it must be a *dull* black, without any shine to it. Rightly done this scheme has the double effect of adding much brilliancy to the picture and eliminating any movement of the sides, top or bottom of the picture, due to vibration of the machine itself.

The strip of picture overlapping on the black is to all intents and purposes invisible, therefore the black edge becomes, in fact, the real edge of the picture. This plan is not practical where a stereopticon picture is thrown on the same screen, unless its height be no greater than that of the moving picture. Usually this would be too small for the stereopticon picture. It is generally possible, however, to have a second, ordinary cloth curtain, which can be brought down in front of the motion picture curtain when it is desired to project stereopticon pictures.

Locating the Screen in the Front of the House is not to be recommended and, unless required by local law, it should not be thus placed, since the effect is not at all pleasing. Those entering and passing out must perforce pass beside the screen. This has the effect of constantly distracting attention from the picture. If the operating room is thoroughly fireproof, as set forth in these pages, there is no need for its being located at the rear of the theater. The argument for having the screen at the entrance is that the operating room, being to the rear, the audience will not be compelled to pass under or by it in leaving, in case of fire, but this argument only holds good where the operating room is neither properly built or equipped, according to the directions set forth in these pages. See page 68.

The Front of the Auditorium, especially its front wall, should not be too ornate, or too light in color. The one has the tendency to distract attention from the picture; the other to render it less brilliant for a given amperage. The ideal front wall, particularly that portion immediately surrounding the screen, is black velvet, draped in graceful folds, of course.

In Fig. 134C we see a screen outlined in black as hereinbefore described. The effect will be found to be most excellent, but would be still further enhanced were the rest of the front wall draped with black velvet, or painted a very dark, dull color. On the other hand, however, it must be conceded that the house would not present so handsome an appearance when the house lights were on. Unless vaudeville be used, however, this is not of especial importance, since the lights will be on only a comparatively short space of time while the audience is present. Conditions and circumstances will alter cases, but ordinarily where nothing but motion pictures and illustrated songs are used, I am a firm believer in surrounding the screen with a background of black ten feet in depth at the least, the first dozen inches to be either black cloth or paint, without the least bit of gloss, and to lie flat on the curtain, the rest to be black velvet, not of the cheapest possible grade either, gracefully draped. If there be a stage, the best possible effect may be produced by setting the screen back as far as may be without interfering with view of that part of the audience seated in side seats, and draping black velvet from screen to proscenium arch on either side, stretching black velvet from top of proscenium to top of screen and painting the floor dull black. This will cost money, but it will produce the best effect that can possibly be had. The same thing can be done by

Fig. 134C.

using cheaper material, even plain black cloth, but of course the richness of setting is not there. Bear in mind, however, that very cheap velvet will not be much of an improvement over ordinary black cloth, and will cost much more. By the use of velvet you are aiming at richness in effect; therefore either "go the limit" and do it right by getting velvet or else merely use plain, black cloth. In any event if there is a stage, and your house is a short one, say less than 75 feet in depth, it is well to set the screen back as far as you can possibly get it, without seriously interfering with the view from side seats. Those in the rear seats will still be close enough to have an ideal view, while to those directly in the front and to the side of the curtain, the picture will be vastly improved over what it would be were it at the proscenium line. There is a double advantage in outlining the screen in black. Not only is there less distraction for the eye, but the effect of added light brilliancy is had without its actuality. This is of advantage since every increase in actual light brilliancy has a decided tendency to accentuate any flicker there may be. With very brilliant light even the more modern three-wing shutters do not entirely get rid of it. By the use of a black outline the light appears much stronger owing to contrast, while actually remaining exactly the same. Thus brilliancy is attained without flicker increase. In large, regular theaters, where a mixed performance is given, it is usually necessary that the screen be placed near the curtain line, so that the stage may be set while the picture is being run. Most of such houses use a single cloth drop, sometimes outlined in black and sometimes not. Such a screen will sway with every breeze, or move when touched by stage hands in setting the stage at its rear. A much better scheme for such houses would be to frame this drop substantially, though lightly, and back it with quarter-inch basswood, or other light lumber. At either side there should be arranged grooves so that the screen would always set in precisely the same spot when lowered. All this is entirely practical, and should by all means be done. It applies, only, of course, to houses having a fly-loft. Many prefer that the whole screen, outside the actual surface used for projection, and two or three inches of that, as before set forth, should be made dull black.

The height of the screen above the floor should be governed by circumstances. Where there is a stage, however, I think the general effect is best if the bottom of the picture is located approximately at the stage floor. I have frequently seen the bottom of the picture located from ten to even as much as fifteen feet above the auditorium floor. A distinct advantage is gained in this way, of course, since it does away with the obstruction to the view sometimes caused by the person seated in front. This is, however, I think, also a distinct disadvantage, and the disadvantage more than outweighs the gain. The disadvantage is that the picture is not shown in the normal level position at which we are ordinarily accustomed to look at such scenes in real life. It rather conveys the sub-conscious impression that one is looking at a picture on the wall; and to this extent the illusion of reality is destroyed. I believe, taking everything into consideration, that the picture should never, unless the conditions are something out of the ordinary, be located more than six feet or, at the most, eight feet above the auditorium floor. One large exhibition hall on 23rd Street, New York City, for some years has been projecting moving pictures upon a screen, the bottom side of which is fifteen feet above the auditorium floor. This produces not only excessive distortion but causes eye strain and is a distinct strain upon the neck of the spectator. This a very extreme case.

Size of the Picture will be governed by local conditions. In this connection several things must be taken into consideration, some of which have already been dealt with. The picture, as projected through the machine aperture, is approximately 11/16 x 15/16 of an inch. It is readily seen that the magnification is, in any event, tremendous. *Remember that every defect in photography, every movement of the film and every jump is increased as the size of the picture is increased.* Also it must be borne in mind that as the picture size is increased the light strength must be rapidly made greater. You have a light strength produced by 30 amperes D.C., let us assume. You are throwing a 12-foot picture. This means that the light is distributed over a space of 108 square feet. Suppose you increase the size to 16 feet. You now have 192 square feet of surface—almost double that of the 12-foot picture, hence the curtain brilliancy obtained from your light is decreased by almost one-half. You must increase the amperage very greatly to secure illumination equal to that of the 12-foot picture. You will therefore see that a large picture is costly, either in current consumption or in sacrifice of brilliancy. See page 335. A 12-foot picture is considered as being "life size." A picture of this size is perfeetly distinct in all its details, to the person of normal vision, 75, or even 100 feet away. It is seldom there is any real reason for the use of a larger picture, so far as distinctness of vision goes. It must be granted that in a large house a 12-foot picture seems too small, especially if the screen is located on a large stage.

The size may be increased very greatly, but it is always at the expense before mentioned. The possible limit of size depends on circumstances, and how much you are willing to expend for current; also mirror screens do not exceed 13½ x 18½ feet in size. For a throw of less than 50 feet, eighteen feet is about the limit, since with a wider picture, optical difficulties are encountered. A very short focal length projection lens is required to project a wide picture on a short throw, and such lenses seldom give sharp definition. With a throw of 75 feet, a 20-foot picture is as large as it is well to attempt. At 100 feet almost any size you can illuminate may be projected. To put the matter concisely, I do not advise the use of a projection lens of less than 3½-inch equivalent focus. This matter will, however, be treated more exhaustively under "Lenses."

A Transparent Screen for projection from the back may be made from a good grade of white lawn, to be had of any dry goods store, stretched tightly on a suitable frame and coated with two or three coats of white shellac. The lawn must be of good quality, and the seams must be carefully made so that they will show as little as possible, though they will show anyhow to some extent. Aside from this, the effect is excellent. The Mirror Screen people put out a transparent screen of glass, presumably ground on one side, but as to the thickness, weight and other details of this screen I am uninformed. There is no doubt but that, so far as effect and brilliancy are concerned, a ground-glass transparent screen is ideal.

A picture may be projected through an ordinary cloth screen, but the cloth should be very white and thin. A very thin grade of muslin, or a tolerably heavy grade of cheese cloth. The effect of such a screen will be very much better, if it be kept wet.

When projecting through a transparent screen, the film must be reversed in the machine—that is to say, the emulsion side must be towards the screen, instead of towards the light, otherwise all reading matter will be reversed (read backwards to the audience).

FOOT SHUTTER

In some cities, it is still required by law that a shutter be placed between the condensing lens and the machine, the same to be held normally closed by a spring as shown in Fig. 134D. The operator is obliged to hold this type of shutter open with his foot, and unless the pedal be made in the best form, it may add very materially to the discomfort of the operator, particularly on an all-day grind.

In Fig. 134D, we have illustrated a most excellent type of this class of shutter. The sketch is largely self-explanatory. The pedal should be placed directly under the edge of the machine table on the operating side, its height from the floor being governed by the height at which the machine sets. With a machine 3 feet 6 inches from table to floor, the top of the pedal should be 8 inches from the floor when the shutter is down. If a film tank is used in place of a take-up, (I believe these tanks are still used in some small towns) it will be necessary to attach a flat strip to the top of the pedal on which to rest foot, since the pedal itself will set up flat against the tank. The front end of the pedal should slide up and down in a slot like figure illustrated in ring, Fig. 134D, which is attached to front wall of operating room. This block should be located so that the pedal will just reach the bottom of the slot when the shutter is wide open. This relieves the strain on the shutter and chain. The shutter should be attached to the pedal by a small brass chain, such as is used

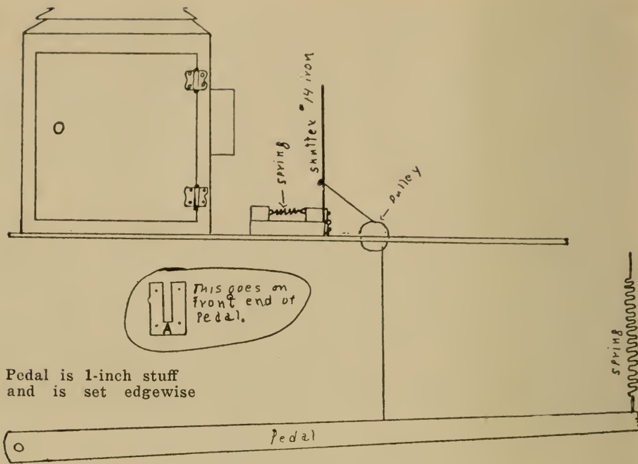


Fig. 134D.

on the flush tanks of toilet rooms. The back end of the pedal may be attached to anything convenient, or a standard may be attached to the floor to which it must be bolted. A shutter made like Fig. 134D, will work and will work right. It will snap shut the instant the operator's foot is removed, and it allows him to vary his position almost at will, so long as he keeps within reaching distance of the pedal.

HOOKING UP FOR A TEMPORARY SHOW

It often occurs that an operator is employed to go out to some small town and give a single show in a church, theater or school house, and very frequently this is not as simple a matter as it seems at first glance. The operator should be very sure that his outfit is complete before starting. Unless he knows the exact throw and size of picture, he should take along at least three focal lengths of M. P. and stereo lenses, viz: A 3½, 4 and 6 inch M. P. lens and a 12, 16 and 21 inch stereo; the latter should be half size lenses. He should, if possible, ascertain the kind of voltage and current supplied, so that he may supply the proper amount of resistance.

In this connection, let it be said that there is a book published by The McGraw Pub. Co., 239 W. 39th St., New York, giving the kind of current, voltage, etc., of every town in the United States and Canada. Its price is $5.00, and every traveling operator should have one. If you do not know the voltage of the current, or its kind, then you should at least take along rheostats enough to handle 250 volts. Examine the whole outfit and be sure that nothing has been left out. I have known of men going out to give a show, only to find on arrival that the machine crank had been left behind, or that no carbons were in the outfit, or that the lamp leads were absent, or without an empty reel, or that the operating switch and fuses had been left behind. An ounce of prevention is worth a pound of cure, therefore be sure before starting that everything is there.

You should have with you at least 250 feet of stranded, rubber covered wire, size No. 6, B. & S. On arriving at the building where the show is to be given, the first thing is to ascertain whether the current is A. C. or D. C., and if the former, whether there is a pole transformer, and if it is or is not large enough to supply current to the arc, plus whatever else it must carry, always remembering that a commercial transformer can safely carry a 50 per cent. overload for an hour or two. If there is any question as to the size of the transformer, you had better see the light plant people about it, and sometimes a couple of good cigars will work wonders in convincing the electrician that the transformer is large enough to carry your load (see transformer, page 142). The next thing is to determine whether the wires entering the building are large enough to carry your arc, plus whatever else they must carry; also the building meter and fuses. The next thing is to determine the best place to connect your wires. If there is a panel board near to where you desire to locate your machine, and it is fed by wires large enough to carry the load, you may connect to the board at the point where feed wires attach. If there is no panel board, or if the panel board feeders are too small, you must carry your wires to the main cut-out and connect there. If the wires entering the building are too small, then it will be necessary to carry your own wires out and connect to the secondary (if there is a transformer), right up close to the transformer, supporting your wires, in any convenient way, high enough so that no one can touch them. In deciding whether the wires entering the building are large enough or not, don't forget to figure the load they must carry, other than the load of your arc. The voltage may usually be ascertained by examining the tags on the lamps, or the meter, or the pole transformer, or by using your test lamp. Having set up your machine and made all electrical connections, strike an arc to make sure that everything is all right. Try out your mechanism to see that nothing has been disarranged in shipment.

Lenses

WHAT may be termed the principal function of a lens, as applied to projection, is to refract all rays of light, striking its surface, emanating from a given point, in such manner that they all reach precisely the same relative point on the screen. This is illustrated in Fig. 135.

In A, Fig. 135, we see arrow BC being projected through pinhole D to EF. Taking the two extremes of arrow BC as example, rays emanate in every direction, as shown, but only the one ray from each point striking hole D can reach screen EF. This means that, while image EF will appear, it will be comparatively very faint, since but one ray from each point of surface on arrow BC is utilized. Such an arrangement would be entirely impossible for ordinary projection. You would only be able to see a very faint image on the screen in a perfectly dark room, if, indeed, you could see it at all with the naked eye when magnified to ordinary projection size. We must, therefore, find some method of projecting the image by which an infinitely greater percentage of the light will be made available, and, at the same time, the sharpness of the image be retained. In B, Fig. 135, we see arrow GH being projected through lens I, the image appearing as JK.

Again, rays from every point of surface on arrow GH go forth in every direction, but we take those from the extremes only, as example. We now find that all rays emanating from point G and striking lens I, are refracted to point J, while all rays from point H are refracted in such manner that they reach point K. If we now take a third point, L, as example, we shall find rays from it will refract to point M and so on until every infinitesimal point of the surface of GH has been projected to its exact corresponding point of the image, and we have a sharply defined perfect representation of arrow GH on the screen. This, in general, is the operation of the objective lens used in projection. It, by no means, however, tells all the story. To project a perfectly true, sharply defined image, without distortion of any kind, requires a lens of perfectly homogenous substance, of combination crown and flint glass to correct chromatic aberration, and with a surface ground to an absolutely true curve at all points; also having perfect polish. Therefore, you see at a glance some of the difficulties to be encountered by its maker. A study of Fig. 135 will show you why the image on the screen is inverted and its sides reversed, without further explanation on that point.

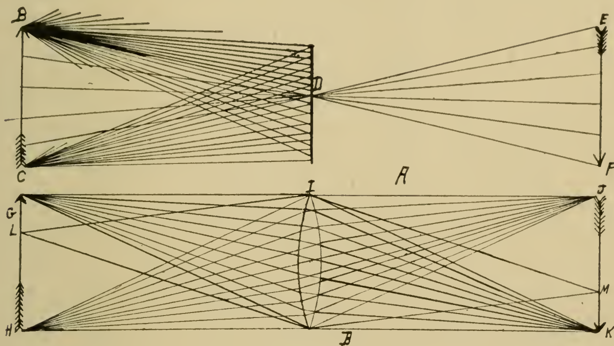


Fig. 135.

The subject of lenses is one which none but the trained optician can hope to understand thoroughly, and it is a very open question how many of them are certain of their ground on some of the questions which arise. The action of a lens is based on the fact that a ray of light passing from a medium of one density to another of different density, at an angle, is bent, or refracted from its course. This is illustrated in Fig. 136, in which 1-2-3-4 represent a sheet of thick glass, the waved line A-B a ray of light which is, for the purpose of illustration, enormously magnified to C-D. Light is supposed to travel in waves, and the cross lines represent the waves. Light waves travel faster in a thin medium than they do in one more dense, hence wave F-E, which strikes and enters the denser medium (glass) at F before it does at G, will travel more slowly from F to H than from E to G, and thus will be bent and its direction altered as shown. As it leaves the glass and re-enters the air, the process will be reversed, and if the two sides of the glass be exactly parallel, the direction, after re-entering the air, will be exactly the same as before entering the glass, but the ray will be to one side of its original path a distance depending on the thickness and density of the glass.

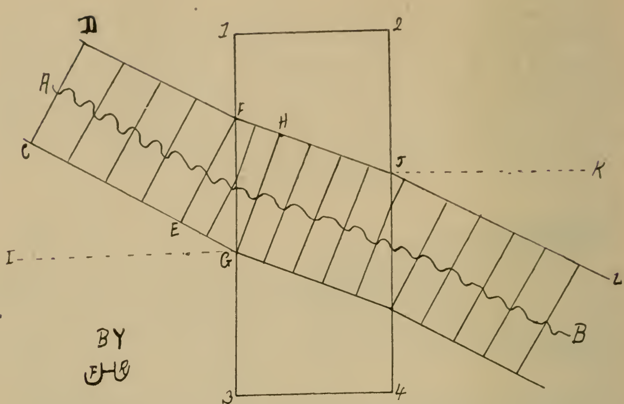


Fig. 136.

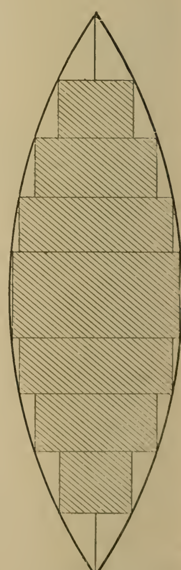


Fig. 137.

To enter exhaustively into the question of light action would consume a great many pages of this book, and it is exceedingly doubtful that the average reader could understand it theoretically. Those interested will find a lengthy discussion of the matter in back numbers of the Projection Department of The Moving Picture World, beginning in April 29, 1911, issue, and running through until August 5.

What we call white light is really a composition of several colors, the combination producing no color at all. In passing through a prism, light is, for reasons not necessary to set forth, separated into its original, or primary colors. It is necessary that the operator know something about this in order to understand certain points about his lenses and their work.

A lens is nothing more or less than a series of prisms of almost infinitesimal size. In Fig. 137, we see this idea crudely illustrated. One point must first be grasped, viz.: that the actual body of a lens is of no optical value whatever, so far as refraction is concerned, except to act as a support for its surface. It is the surface of the lens which does the work. To understand the foregoing statement one must grasp the fact that the refraction of the light ray (amount it will be bent, or deflected from its path) depends upon two factors, viz.: the angle at which the ray encounters the glass and the density of the glass. Once having entered the glass, the course of light ray will be perfectly straight until it again emerges into the air, at which point it will again be bent, or refracted in proportion to the angle formed between the lens surface and the direction of the ray.

In Fig. 137, the unshaded spaces represent the prisms formed by the curved surface of the lens and the shaded portion shows the body of the lens, useless except as a support for the surface. As a matter of fact the prisms are extremely minute as to size (about the area of the point of a cambric needle), since the lens is curved, hence its surface is constantly changing form. The idea may perhaps be more clearly conveyed in Fig. 138. At A we see a series of prisms.

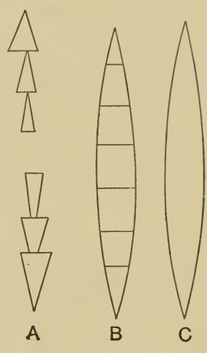


Fig. 138.

They represent what would be left if glass body of lens C were removed, leaving only the curved sides, and the glass, out to a line parallel with the center line of the two halves of the lens and bisecting the prism at its thin point. At B the lens is divided by horizontal lines the same depth as the prisms at A. It will be observed that as the lens center is approached the prisms become thinner, presenting flatter, more nearly parallel surfaces; hence rays striking near the axis of the lens would not be refracted nearly so much as would those striking the more acute sides of the prisms nearer the outer edge of the lens. It follows then that a ray striking the exact center of the lens would pass straight through and not be refracted at all, whereas one striking a little to one side of the center would be bent just a trifle, and one further from the center would be bent still more, and so on until the edge of the lens is reached, where the ray is bent a great deal. Now the lens is ground to an absolutely perfect spherical form, or rather to the shape of a section of a perfect sphere. If you stop and think a moment you will see that this means that every portion of the lens which is, for example, exactly one inch from the center of the lens, is inclined precisely the same, in relation to a line passing through the axis of the lens; hence the rays striking the lens at any point exactly one inch from its center will be bent exactly the same amount, and toward a common point. It also follows that rays striking at any other point on the lens will be bent more or less, according to the angle, but always to a common point.

It also follows that the distance of this common point to which all rays will be directed (focused, we term it) will depend on the curvature of the glass. (Refractive index also enters into the matter, but its introduction would only tend to confuse an exceedingly difficult subject). That is to say, the flatter the lens (the less its curvature) the farther away from the lens will be the point of focus. Remembering that a lens is always a section of the surface of a true sphere, we begin to see why the lens of long focal length is flatter—has less curvature—than one of shorter focal length.

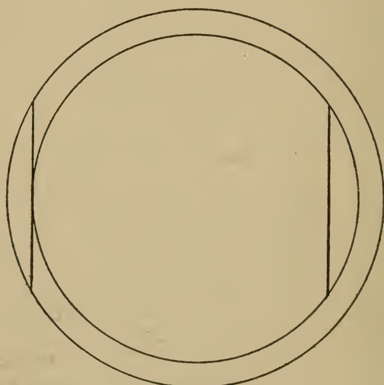


Fig. 139.

Let us take the plano-convex lens for example—the regular condenser lens. If you take a glass ball 7½ inches in diameter, and on its surface scribe a circle 4½ inches in diameter, and then could saw off the section bounded by the circle you would, after polishing the flat surface, have a 7½ inch plano-convex lens. If the ball be 6½ inches in diameter, you would have a 6½ inch lens. That is to say: A lens which would focus parallel rays of light, so that an image would be formed 6½ inches from its surface. It would also focus the rays to a point, further on, as shown in Fig. 139.

Theoretically this lens would bring the rays to a perfect point Fig. 139A, and if the lens were perfect, it would do so in fact, but it is not perfect, and no lens made of one piece of glass is ever perfect. Such lenses are subject to faults, which it would require too much space to explain in detail. In order to actually focus the rays of light to a perfect point, as shown in Fig. 139A, the lens must be "corrected," by the addition of a second lens made of a different kind of glass. Perhaps it will be well to consume some space in a brief explanation of this property of, or rather, fault of lenses, though such an explanation will necessarily be incomplete.

As has already been set forth, the surface of a lens is really nothing but a series of minute prisms. It is also a very well-known fact that what we term "white" light is really a composition of a number of colors. When what we call white light is passed through an ordinary prism of glass it is separated more or less into its primary colors, or, in other words, into the colors of which it is composed. The ordinary plano-convex is an uncorrected lens and always carries the fault of chromatic aberration, which is the property, already described, of separating the

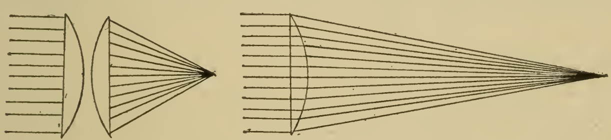


Fig. 139A.

light to some extent into its component parts. This explains why you see a fringe of color at the edge of the spot of the cooling plate of the machine. Inasmuch, however, as the projection lens is a corrected lens, which does not have this fault, the chromatic aberration of the condensing lens does no material damage. The uncorrected lens, however, has a second and more serious fault, viz: Spherical aberration. Spherical aberration is due to the use of spherical surfaces. It may be described as the inability of a lens to focus, or bend, all rays to a point at the same distance from the lens. In other words, the rays passing through the edge of an uncorrected lens do not focus or bend to the same point as those passing through nearer its center. This is diagrammatically explained in Fig. 140.

You have no doubt noticed, that when your machine head is off and the arc is burning, it is impossible to bring the rays of light from the condenser down to a fine point. The explanation of this lies in Fig. 140. It is due to spherical aberration. I do not know that spherical aberration in the condenser lens, unless excessive, does material damage. I believe that under certain conditions it will cause a ghost on the screen. But whatever faults of this kind we may tolerate in the condenser lens, there must be nothing of the sort in the projection lens, which is the image-forming lens of the combination. This latter must in all cases be a thoroughly corrected lens. You will have observed that projection lens sets are composed of apparently three separate lenses, two at the rear end and one at the front end of the tube. As a matter of fact, there are four separate lenses, but the two front lenses are cemented together so that without previous knowledge or on close inspection you would suppose

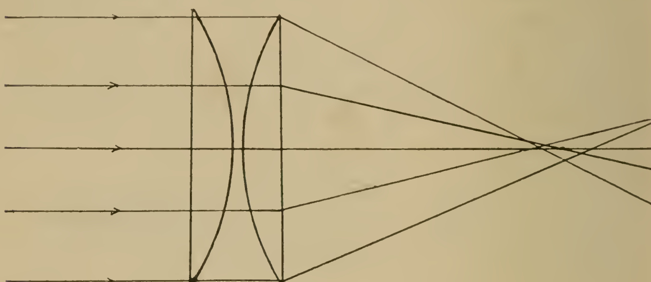


Fig. 140.

them to be one lens. Without entering exhaustively into the whys and wherefores, I will simply say that the reason for the use of two lenses at each end of the tube is for the purpose of correcting spherical and chromatic aberration and other faults, so that the lens will project light which is free from color and focus the rays of light to a pin point on the screen.

Now let us examine into the means by which an image is formed. Both the projection and stereopticon lens must have the faculty of bringing all light rays emanating from a certain pin point on the photograph to a corresponding pin point on the screen, otherwise there will be a lack of "definition" and the image will be more or less blurred. The best possible test for correctness in a lens is the projection of an image laid off in parallel cross lines, as shown in Fig. 141.

At A we see no distortion whatever; at B there is a slight barrel-like distortion, or curvature of the lines. The lens which projected B was not a good lens, whereas the lens that projected A was practically perfect. This test is best made by cutting a strip of mica the exact width of a film, or stereo slide, and laying it out in checker-board form, as per Fig. 141, making the lines with some sharp instrument, but being careful to have them perfectly straight, and perfectly parallel to each other.

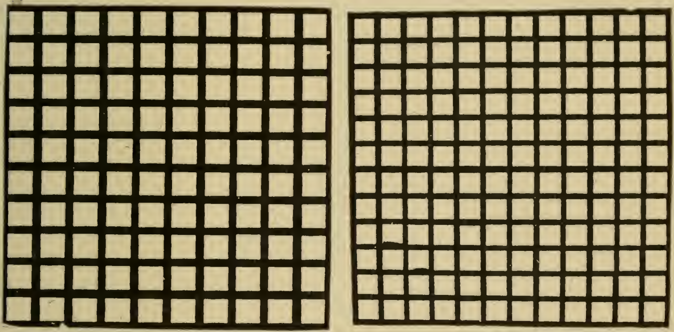


Fig. 141.

As has been said, a lens must focus all rays of light emanating from a pin point in the photograph to a corresponding pin point on the screen. The distance at which this focusing will be accomplished depends, within limits, upon the distance of the film from the lens. This is diagrammatically illustrated in Fig. 142. We here see arrow A being projected, and focused at point 1; that is to say: With the arrow at the distance from the lens,

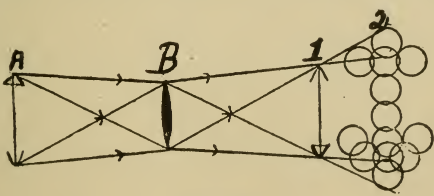


Fig. 142.

as shown, the rays of light will meet and cross at point 1, when they again diverge. If the screen be placed at point 2, the arrow remaining as shown, instead of having an image at 1, each portion of arrow A, would be represented by a ring, and there will be a blur instead of an image. If the distance of arrow A from lens B is altered, then the distance at which these rays of light meet and cross, would be altered, and the screen would necessarily have to be moved at a greater or less distance from the lens. This explains why it is necessary to move the lens in or out in order to focus the picture on the screen.

The common, and usual, method of representing the passage of light through a projection lens is to show the rays as being focused to a point midway between the two combinations of the projection lens, as shown at Fig. 143.

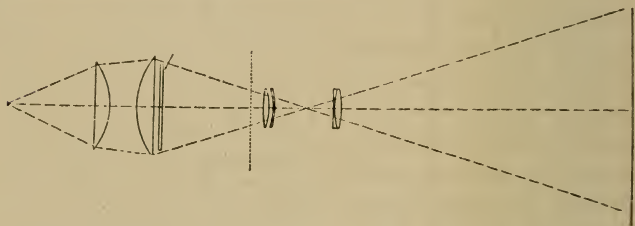


Fig. 143.

This, however, does not appeal to me as being correct. I do not see how it can possibly be, and I do not believe it is a correct representation of the action of light through a projection lens. I am of the opinion, rather, that the light passes through the lens, as shown in Fig. 144, which is taken from a most excellent work on photographic lenses, by Conrad Beck and Herbert Andrews, London. And now having dealt very briefly with a few of the vast numbers of technical points which arise, the instant one attempts to inquire into the action of light through lenses, let us take up something more nearly of a practical nature.

The question is frequently asked as to whether or not the size of a picture can be increased by bringing the two combinations of the lens closer together, or whether the size of the picture can be made smaller by increasing the distance between the two combinations of the projection lens—that is to say, by lengthening or shortening the lens barrel. Yes, this can be done. Bringing the two combinations of a projection lens nearer to each other, or separating them a greater distance, would increase, or decrease the size of the picture, but nine times out of ten it would also very materially injure the definition. Therefore I cannot advise that any such thing as this be attempted. If your lens is not projecting a picture large, or small enough, you had better procure another one that will.

Size of Picture.—It is frequently asked as to whether or not the same lenses can be used to project a picture at a greater distance, or at a shorter distance. They can, but it must be understood that if the distance be made less, then the picture will be smaller, and if the distance be made greater, the picture will be larger. The exact increase or diminution in size can be easily figured. It is one of those things to which it is merely necessary to apply a little common sense. Supposing you have a

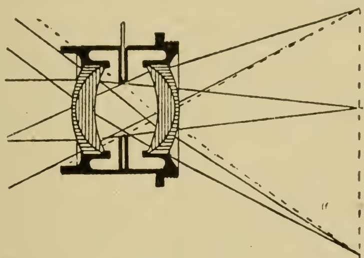


Fig. 144.

lens which projects a 10-foot picture at 60 feet (when we say a 10 foot picture, we mean, of course, a picture 10 feet wide). Now, if you will stop and think a moment, you will readily see that if the width of the picture be divided by the number of feet it is projected, the result will be the fraction of a foot its width increases with each foot of distance, hence we have $10 \div 60 =$ 1-6 of a foot, or two inches, which the light spreads to each foot of distance between lens and screen. In proof of this, multiply 2 inches by 60, and we have 120 inches, which divided by 12, equals 10 feet. Now, if we wanted to move our screen back by 5 feet, then we would have 5 feet additional throw, hence we would have $2 \times 5 = 10$ inches additional width of picture, or if we wanted to bring the screen 4 feet nearer the lens, then we would have $2 \times 4 = 8$ inches less width of picture.

A projection lens which does not give a sharp definition can sometimes be improved by cutting a paper ring of such width that it will cover about ⅛ of an inch of the lens around the edge, and clamping it into the mount of the front or rear combination. It must be understood in this connection that the weakest part of the lens is always at its outer edge. If there is any spherical aberration that is where it will be found. This is often of benefit where the machine sets to one side of the screen, and one side of the picture is therefore more or less out of focus.

MEASURING LENSES

Measuring lenses is something every operator should thoroughly understand. There is a rather general relation between the focal length of the condensing lens, and the focal length of the projection lens, and it is frequently advisable that the operator be able to measure and determine the exact focal length of his condenser lenses. This may be done as follows: Pin a sheet of white paper on the wall of a room opposite a window, hold the lens up with the flat side toward the wall and carefully focus, through the open window, some trees, or something at a distance outside of the window, on the paper screen. Be sure to get the lens in the exact position where the focus is sharpest, and then measure from the flat side of the lens to the wall, making note of the exact distance. Now, turn the lens around, with the convex side toward the wall, and again carefully focus the outdoor scene upon the paper screen, measuring again from the wall to the flat side of the lens. Make note of this measurement also. It will be found that the two measurements differ considerably, and the measurement of the shorter one plus ½ the difference between the two will be the focal length of the lens as nearly as it can be determined by measurement. For instance: Supposing one measurement is 6 inches, and the other 7 inches, this means that 6 inches plus one-half the difference between 6 and 7 inches (½ inch) is the true focal length of the lens itself. Therefore, it is a 6½ inch lens. It is a practical impossibility to measure condensing lenses accurately, since there is so much spherical aberration that the focusing of the picture with absolute sharpness is impossible. Still, the length of the lens can be arrived at closely enough, for all practical purposes. The measuring of a projection lens is a very simple operation. There are two ways of designating the focus of a projection lens. Film exchanges usually use the b.f., or back focus, whereas the lens manufacturer uses e.f., or equivalent focus. Therefore it is necessary that, in ordering lenses of a given focal length, one should be careful to state whether one means b.f. or e.f.

To measure a projection, or stereopticon lens, pin a sheet of paper on a wall opposite a window. Hold the lens square with the paper screen and, having opened the window, focus some distant object on the paper screen, being careful to get it as sharp as you possibly can. Now measure from the wall to the face of the lens nearest the screen, and *that measurement will be the b.f.,* (back focus) *of the lens.* If, instead of measuring from the back lens to the screen, you measure from a point half way between the front and back combinations of the lens (half way between the lenses at either end of the tube), to the paper screen, *that measurement will be the e.f.* (equivalent focus) *of the lens.* This we see diagrammatically illustrated in Fig. 145.

Let me caution you to use some distant object for focusing when measuring lenses, since it is presumed that the rays of light from the object will enter the lens in parallel lines. If the object is too near the lens, the rays will enter at a sufficient angle to materially affect the result. Any object which is 100 feet distant will be all right, and even an object 25 feet away will not be close enough to affect the result very much. However, the farther away the thing focused is, the better. It is possible to focus an incandescent light and thus measure a lens at night, but if you do this, get as far away from the lamp as possible or your measurement will not be correct.

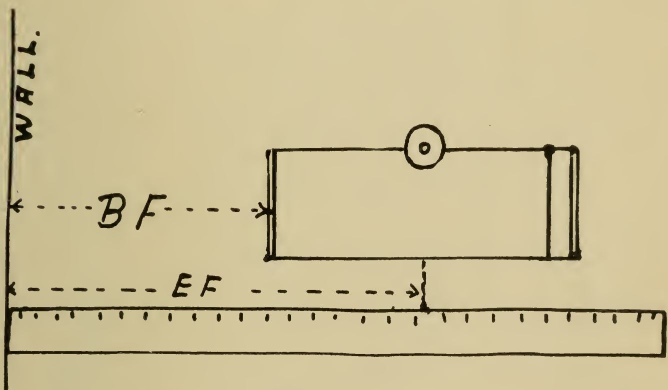


Fig. 145.

The use of these measurements becomes apparent when we say that the size of picture which will be projected by any lens at a given distance from the screen will depend entirely upon the focal length of that lens. The shorter its focal length, the larger will be the picture at a given distance, and the greater its focal length, the smaller will be the picture at a given distance, thus: A 4 inch e.f. lens will project a much larger picture at 50 feet than will a 6 inch e.f. lens.

There are a number of tables put out by lens manufacturers, and others, designed to give the size picture a lens of given e.f. or b.f. will project at any given distance. These tables are

TABLE X

Showing Size of Screen Image When Lantern Slides Are Projected

Size of Mat Opening, 2¾ x 3 Inches

Equiv. focus Inches	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
5	8.0	10.8	13.5	16.3	19.0								
	8.8	11.8	14.8	17.8	20.8								
5½	7.3	9.8	12.3	14.8	17.3	19.8							
	7.9	10.7	13.4	16.1	18.8	21.6							
6	6.6	8.9	11.2	13.5	15.8	18.1	20.4						
	7.3	9.8	12.3	14.8	17.3	19.8	22.3						
6½	6.1	8.2	10.4	12.5	14.6	16.7	18.8						
	6.7	9.0	11.3	13.6	15.9	18.2	20.5						
7	5.7	7.6	9.6	11.6	13.5	15.5	17.5	19.4					
	6.2	8.3	10.5	12.6	14.8	16.9	19.0	21.2					
7½	5.3	7.1	8.9	10.8	12.6	14.4	16.3	18.1					
	5,8	7.8	9.8	11.8	13.8	15.8	17.8	19.8					
8		6.6	8.4	10.1	11.8	13.5	15.2	17.0	20 4				
		7.3	9.1	11.0	12.9	14.8	16.6	18.5	22.3				
8½		6.2	7.9	9.5	11.1	12.7	14.3	16.0	19.2				
		6.8	8.6	10,3	12.1	13.9	15.6	17.4	20.9				
9		5.9	7.4	8.9	10.5	12.0	13.5	15.1	18.1	21.1			
		6.4	8.1	9.8	11.4	13.1	14.8	16.4	19.8	23.1			
9½		5.6	7.0	8.5	9.9	11.4	12.8	14.2	17.1	20.0			
		6.1	7.6	9.2	10.8	12.4	14.0	15.5	18.7	21.9			
10		5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8		
		5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.8		
12			5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.4	
			6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.3	
14				5.6	6.6	7.6	8.6	9.6	11.6	13.5	15.5	17.5	19.4
				6.2	7.3	8.3	9.4	10.5	12.6	14.8	16.9	19.0	21.2
16					5.8	6.6	7.5	8.4	10.1	11.8	13.5	15 2	17.0
					6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
18					5.1	5.9	6.6	7.4	8.9	10.5	12.0	13.5	15.1
					5.6	6.4	7.3	8.1	9.8	11.4	13.1	14.8	16.4
20						5.3	6.0	6.6	8.0	9.4	10.8	12.2	13.5
						5.8	6.5	7.3	8.8	10.3	11.8	13.3	14.8
22							5.4	6.0	7.3	8.5	9.8	11.0	12.3
							5.9	6.6	7.9	9.3	10.7	12.0	13.4
24								5.5	6.6	7.6	8.9	10.1	11.2
								6.0	7.3	8.5	9.8	11.0	12.3

Example: With a lens of 10-inch focus at a distance of 20 ft. the screen image will be 5.3 x 5.8; at 25 ft., 6.6 x 7.3; at 30 ft., 8.0 x 8.8; at 50 ft., 13.5 x 14.8 etc.

TABLE XI

Showing Size of Screen Image When Moving Picture Films Are Projected

Size of Mat Opening, 11/16 x 15/16 Inch

Equiv. focus Inches	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
2⅛	4.8	6.4	8.0	9.6	11.3	12.9	14.5	16.1					
	6.5	8.7	11.0	13.2	15.4	17.6	19.8	22.0					
2½		5.4	6.8	8.2	9.6	10.9	12.3	13.7	16.4				
		7.4	9.3	11.2	13.1	14.9	16.8	18.7	22.4				
3		4.5	5.7	6.8	8.0	9.1	10.3	11.4	13.7	16.0			
		6.2	7.7	9.3	10.9	12.4	14.0	15.6	18.7	21.8			
3½			4.9	5.8	6.8	7.8	8.8	9.8	11.7	13.7	15.7		
			6.6	8.0	9.3	10.6	12.0	13.3	16.0	18.7	21.4		
4			4.2	5.1	6.0	6.8	7.7	8.5	10.3	12.0	13.7	15.4	
			5.8	7.0	8.1	9.3	10.5	11.6	14.0	16.3	18.7	21.0	
4½				4.5	5.3	6.2	6.8	7.7	9.1	10.6	12.2	13.7	15.4
				6.2	7.2	8.4	9.3	10.5	12.4	14.5	16.6	18.7	21.0
5					4.8	5.4	6.1	6.8	8.2	9.6	10.9	12.3	13.7
					6.5	7.4	8.4	9.3	11.2	13.0	14.9	16.8	18.7
5½					4.3	4.9	5.6	6.2	7.4	8.7	9.9	11.2	12.4
					5.9	6.7	7.6	8.4	10.2	11.9	13.6	15.3	17.0
6						4.5	5.1	5.7	6.8	8.0	9.1	10.3	11.4
						6.2	7.0	7.7	9.3	10.9	12.4	14.0	15.6
6½							4.7	5.2	6.3	7.3	8.4	9.6	10.6
							6.4	7.1	8.6	10.0	11.4	13.0	14.5
7							4.4	4.9	5.8	6.8	7.8	8.8	9.8
							6.0	6.6	8.0	9.3	10.6	12.0	13.3
7½								4.5	5.4	6.4	7.3	8.2	9.1
								6.2	7.4	8.7	10.0	11.2	12.3
8									5.1	6.0	6.8	7.7	8.5
									7.0	8.1	9.3	10.5	11.6

EXAMPLE: With a lens of 5½ inch focus at a distance of 35 ft. the screen image will be 4.3 x 5.9; at 40 ft., 4.9 x 6.7; at 45 ft., 5.6 x 7.6 etc.

useful as applied to stereopticon lenses, but they are of little value as applied to projection lenses. This is by reason of the fact that the size of the picture is based upon a given width of aperture, which in the case of the stereopticon, is supposed to be 3 inches, but which actually varies widely with each set of slides (the aperture in the case of the stereopticon is the width of the standard slide-mat), hence, by reason of this variation in slide-mats, it is impossible to figure the size of a stereopticon picture with any degree of accuracy and a table will usually answer as well as measurements.

As applied to the projection lens, these tables are not nearly as satisfactory as measurements, for the very simple reason that they are figured for a given width of aperture, whereas these apertures vary considerably, and the only way you can possibly arrive at anything like an accurate determination of the width of picture you will get from a lens of a given e.f., or b.f., will be to measure the exact width of the aperture of your machine, and bear in mind the fact that this measurement must very exact.

To determine the size picture a projection lens will give at a certain distance, proceed as follows: Measure the width of the aperture of your machine accurately, with a caliper, and measure the distance from the center of the lens combination to the screen. Multiply the distance from the lens to the screen, in feet, by the width of the aperture in fractions of an inch, and divide this result by the width of the picture you desire, in feet. The result will be the e.f. of the lens required to project that picture, and this will be as close as you can possibly get at it by figuring. It must be understood, however, that projection lenses are cheap lenses, and cheap lenses, like all other cheap things, are notoriously inaccurate; therefore, you cannot expect to arrive with certainty at exactly the result you desire.

The stereopticon lens is figured in the same way, except that instead of measuring the aperture width, you take three inches as the average width of the slide-mat; hence multiply the distance from the screen to the lens by 3 and divide this result by the width of picture you desire. The result will be the e.f. of the required lens as nearly as it can be determined. I append hereto the before mentioned tables, one for projection and one for stereopticon lenses, though I cannot recommend their use. It is also entirly practical to make other measurements of practical value as follows:

Size of Image.—This can be determined by multiplying the difference between the distance from lens to screen and the focal length of the objective, by the width of the aperture and dividing the product by the focal length of the lens. For example: Let l be the projection distance, 40 feet (480 inches); S, the slide mat, 3 inches; F the focus of the lens, 12 inches; then we have the formula (in which d is the size of image):

$$d = \frac{S\ (L - F)}{F}$$

Substituting for the letters their known values, we have:

$$d = \frac{3\ (480 - 12)}{12} = 117 \text{ in. or } 9\tfrac{3}{4} \text{ feet.},$$

as the size picture a 12 inch e.f. stereo lens will project at 40 feet, provided the slide mat be just 3 inches wide.

Distance from Slide to Screen.—With the other factors given we get this by multiplying the sum of the size of the image and width of the slide mat, by the focal length of the lens; dividing this product by the size of the slide mat, thus:

$$L = \frac{F\ (d + S)}{S}$$

Substituting values, $L = \frac{12\ (117 + 3)}{3} = 480$ inches $= 40$ feet.

It need hardly be said that in order to secure good results, both the condenser and projection lenses, particularly the latter, must be kept scrupulously clean. Not so very long ago a New York operator induced me to visit his operating room on the plea that while his lens had always given a good picture up to a time some two weeks previously, when he had taken it apart and cleaned it, the definition was now poor. I found the lens had been put together properly, but a close examination showed that after cleaning the inner surface of the back combination, he had inadvertently allowed it to touch one of his hands. The touch was very light and the mark could only be seen by very close examination. But it was there nevertheless, and it ruined the definition of the picture. I tell you this to impress upon you the fact that even the slightest touch with the fingers on a projection lens, unless carefully cleaned off, even though the mark be almost invisible to the naked eye, will certainly injure the work of the lens. It is a good plan to slip out the condensing lenses every day, before starting the run, and polish their surfaces by breathing on them, when cold, and rubbing with a soft piece of very clean cheese cloth, or any soft rag that is clean. An old handkerchief is ideal for this purpose, provided, of course, it be perfectly clean. These lenses may also occasionally be washed in wood alcohol (I say "wood" alcohol because it is much cheaper than the other kind, and serves exactly the same purpose), polishing, however, very quickly, before the alcohol dries.

The inner end of the projection lens should be carefully examined every day to see that there is no oil on its surface. A spot of oil will spread on the surface of the glass and seriously injure the work of the lens. It should be washed off with alcohol, carefully polishing afterward. Should your picture suddenly develop lack of definition (focus), that is the first thing to look for—oil on the inner end of the projection lens. The projection lens should be taken apart once in a while, but not too often, however, and the surfaces of all its lenses be thoroughly washed with wood alcohol, carefully polishing afterward. In replacing, be careful to get the heaviest convex surface of all lenses towards the screen—not towards the light. That is to say—the heaviest bulge of the lens should go towards the screen. This is illustrated in Fig. 146.

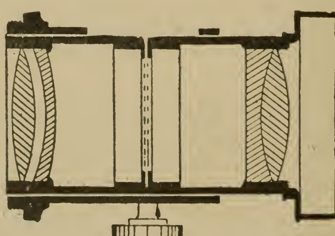


Fig. 146.

As a rule, you will find, upon taking the lenses apart, that there are apparently but three of them. This, however, as has been already explained, is by reason of the fact that the front lenses are cemented together. In putting the lens back, be very careful and do not touch the surface of the glass; also be careful to clamp the lenses down tightly in their respective mounts, and do not get the threads of the mounts crossed.

The front combination is cemented together, usually with Canadian Balsam. Once in a great while this balsam will melt and run down between the lenses. In such a case, it is possible to take the lenses apart and clean them; but the operator had better not undertake the job since he cannot successfully re-cement them together again. It is best in such a case to lay the lens aside, taking out the front combination and sending it to the manufacturer for recementing. In case you attempt to do the job yourself, however, the two lenses can be separated by laying them in warm water and bringing it to a boil. Take the lens out and quickly slide the lenses apart. You may have to repeat this operation several times and you will have to shove pretty hard and instantly after removing the lens from the hot water. Do not try to pry the lenses apart. If you do, you will ruin the whole thing.

It will doubtless be news to the operator to know that certain kinds of glass can and will rust. It is, nevertheless true, that certain kinds of glass will rust, or corrode just like metal. This is due to the fact that these glasses contain a large percentage of metal, and it is the metal in them which rusts. I have never known but one or two cases of this fault in projection lenses, but it is mentioned for the reason that its presence is possible.

Of late there has been much trouble with discoloration of condenser lenses. Some turn pink and others turn purple. This fault is due to excess of one of the ingredients of which the glass is made. Such lenses are worthless for projection. They injure the light very materially, and should be rejected immediately and returned to the seller. The question is often asked as to whether or not there is sufficient difference between the cheap condensing lens and the costly one to justify the payment of the difference in price. In reply to this I would say that it is a question which will have to be decided by each individual operator and manager for himself. Beyond any question of a doubt, the high-class condensing lens will contain much less spherical aberration and should produce much better all-around results. But, on the other hand, they are just about as liable to break as are the cheaper ones. There will, however, doubtless be a little improvement in this latter respect, since the more costly lens should have more even density and stand the shock of expansion and contraction somewhat better than the cheaper article.

As to the exact relation between the condensing lens and the projection lens, it is fairly safe to say that with a projection lens of less than 3½ inches e.f., two 6½ condensing lenses will give the best results. With a projection lens between 3½ inches and 4½ inches e.f., one 6½ and one 7½ inch condensing lens will give the best results. With a projection lens of greater e.f. than 4½ inches, it is most likely that the best results will be obtained by the use of two 7½ inch condensing lenses, except where the *e.f. of the projection lens* is very long, in which case special condensing lenses of long focal length should be obtained.

I cannot guarantee the above figures. The better way, usually, is to get two 6½ and two 7½ condensing lenses and experiment, using the combinations which give the best results. Ordinarily, when a condenser set is composed of two lenses of different focal length, the lens of shorter focal length should be next the light.

The Matter of Condenser Breakage is one of great importance to the operator, and it is one of the most difficult propositions he has to deal with. Many and diverse are the remedies which have from time to time been proposed, but what will stop the trouble in one instance does not seem to have any effect at all in another. Some operators claim to have stopped condenser breakage by placing the lenses in cold water, bringing the water to a boil, and allowing it to cool off slowly, repeating the operation several times. Other operators have had success by placing their spare condenser lenses in the oven of the kitchen range at home, leaving them to be alternately heated and cooled for several days. Others have claimed to stop the trouble by keeping their spare condensers on top of the machine lamphouse where they were alternately cooled and heated. But let it be said that still other operators who have tried these various schemes have pronounced them as of no value whatever.

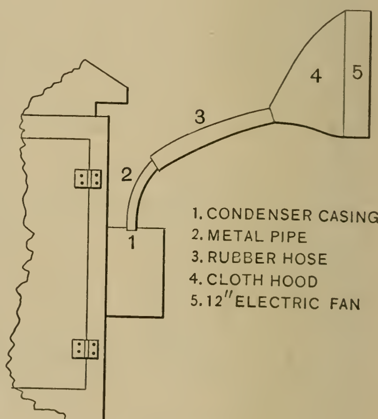


Fig. 147.

One ingenious operator reported having stopped the trouble of condenser breakage by attaching a metal pipe to the condenser casing, placing a hood over an ordinary wall fan, connecting the hood to the pipe, and forcing a constant stream of cold air through between the lenses, as per Fig. 147. I am not prepared to say that this scheme would work in all cases; but it looks reasonable, and might really be of much value.

If I were to set forth all the different schemes presented on this subject, I could almost fill a book with them. I am of the opinion that the following points are the governing factors in condenser breakage: (a) Excessive heat, due to a tightly closed lamphouse or to a heavy amperage, and the sudden cooling of the back lens by shutting off the arc and opening the lamphouse door. (b) Lenses fitted too tightly in a round mount. (c) Lenses clamped against a metal mount, and not touching its surface evenly all around.

The best general advice which can be given consists of the following: Never use a lens that fits tightly in its mount—that is, of such diameter that it fits snugly in a round mount. If it fits tightly, take it to a grindstone and grind its edge down until there is at least 1-16 inch play between the lens and the mount. The glass will expand with the heat more than the metal will, and if the lens fits snugly in one of the round mounts it will break every time, due to the enormous pressure of the glass against the metal. Keep the back of your lamphouse open all the time, unless it is forbidden by local law. There is no danger whatever in so doing. Regardless of what the underwriters, none of whom are practical operators, or the authorities of the various cities, none of whom are practical operators, may say, there is absolutely no danger whatever through allowing the back of the lamphouse to be open. In many of the foreign countries where 70, 80 and even 90 amperes is the rule, rather than the exception for projection, the authorities do not require that the back of the lamphouse be closed. Nor is it closed. And nobody has ever heard of anything being set on fire by reason of the back of the lamphouse being open. You could hang a whole reel of film within two inches of the rear of an open lamphouse, and it would hang there until the Day of Judgment, so far as its catching fire from the arc is concerned. I therefore say that unless the local law specifies otherwise, keep the back of your lamphouse open, but do not allow the draft from a fan to strike it, or to strike the lamphouse at all for that matter, since if you do it is very likely that your condensing lenses will break. I am of the opinion that there is very little danger of breakage so long as the heat in the lens can be kept down below a certain point. I base this assertion on the fact that while the front lens gets very hot (put your finger on it if you do not believe it), and is exposed to every vagrant breeze that blows, it seldom or never breaks. To my mind, it therefore follows that the keeping down of the heat of the lamphouse to as low a degree as possible, by ample ventilation of the lamphouse, will go farther than any one thing in reducing condenser breakage.

Motor Driven Machines

MOTOR driven machines are allowed in some cities, under certain restrictions, and are not allowed at all in others. The objection to the motor-drive is the temptation for the operator to "let George do it," the motor representing "George." The place for the operator is beside the machine, with his eye glued to the picture on the screen every instant the machine is running. The argument for compelling the operator to run his projector by hand is that he is obliged to remain right there, where he belongs. With a motor drive he usually does not remain constantly beside the machine, ready for instant action should anything in the way of film or machine trouble occur. I am obliged to agree with this view. I would very much like to see the operator relieved of the drudgery of cranking the machine, but I am of the opinion, strengthened by close observation, that, aside from the danger involved through the operator not being right there in operating position, projection almost invariably suffers, at least to some extent, where the motor drive is used.

The really high class operator, who produces high-class work on the screen, must and will vary his speed to suit the subject being projected. This often involves changing speed several times during the projection of an ordinary reel. Moreover, he will adjust his light a little at a time, and often; particularly is the latter true of the alternating current arc. He must not and will not remove his gaze from the picture, since even so little as ten seconds may allow a preceptible discoloration of the light to appear at top or bottom of the screen. The only feasible scheme of compelling the operator of a motor-driven projector to remain where he belongs, is, I believe, to construct a platform, the idea of which is imperfectly illustrated in Fig. 148. 1 represents two copper plates, which are separated when the platform is unoccupied by the operator. 2 is insulating material under lower plate, and 3 is insulation between iron support, or hanger, and copper plate. 5-5 and 6-6 are two of four coil springs, their receptacles and support for top section of platform which rests on the springs. 7 is a conduit leading from top section of platform to motor connections. X 1 is wire leading from line to upper copper contact plate and X 2 is line from lower contact plate to one of the motor connections. The other motor wire runs direct from wherever the feed is taken from to motor, of course. The springs must be of such strength that it will require not less than 100 pounds on the platform to bring the two copper plates into contact, thus closing the motor circuit. The view, as shown in Fig. 148, is of course, an end, or side sectional view, and only shows two of the four necessary springs, the intention being merely to convey the idea, leaving the individual to work out the details.

By this plan the operator would be absolutely anchored right there beside the machine, where he should be, every moment the machine is running. The instant he steps off the platform the motor circuit will be broken, and the machine will stop. The platform should be locked shut by the manager, or, better still, sealed by the city inspector. There would be nothing to get out of order, except the rather remote possibility of a spring breaking, and that would simply operate to keep the motor circuit closed all the time. The motor circuit would, of course, have its usual switch in addition to the platform. To make such a plan doubly effective, there should be penalty of instant dismissal and loss of license attached to "doctoring" the platform. The oper-

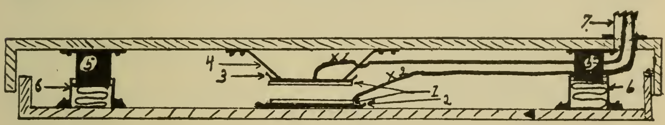


Fig. 148.

ator could hardly keep a 150-pound weight in the operating room where such a platform was used without exciting suspicion. The size of the platform should be about 18 x 36 inches. It need not be more than four inches in height, and three could be made to serve. With such an arrangement, or its equivalent, I would heartily recommend the use of motor drives. It would relieve the operator of what is pretty hard labor, when continued steadily for several hours. It would also give him better opportunity for close observation of his projection on the screen, and the more perfect regulation of speed and light. Some operators may criticise me for insisting on their being literally compelled to remain beside the machine while it is running. To such I have no apology to make. The right kind of man will experience no hardship, for the very simple reason that he will stay right there anyhow.

Methods of Connecting a Motor to the Machine. There are many methods. One thing, however, let me impress upon you, viz: Never belt to the machine flywheel. The flywheel bearing carries considerable weight. It is for high speed. Its bearings will wear pretty fast without the added friction of motor belt pull. Its shaft usually carries the cam of the intermittent movement. Most projecting machine manufacturers will provide a regular motor drive attachment for their machines, and it should by all means be used. Its use will more than repay its cost in the saving of repairs, as against the fly-wheel belting plan.

Fig. 149.

In Fig. 149 we see the unique, but effective plan of motor drive connection used at the Arcadium Theater, Washington, Pa. The machines are both run by one motor, connection being made through a long counter-shaft, carrying a pulley in its center and one at either end. Using this plan, shifting from one machine to the other may be accomplished in several ways, without disturbing the motor. The countershaft may be in three pieces, with friction clutches carrying either end. It may be in two pieces, as I think is the case in the illustration, with two pulleys close together, so that motor belt may be shifted from one to the other. It may also be accomplished by means of a loose belt from countershaft to machines, after the plan shown in Fig. 151. This scheme has the advantage of only requiring one motor. Another plan is shown in Fig. 150, though in this case the belt seems to attach to the flywheel. An objection is that it brings the motor

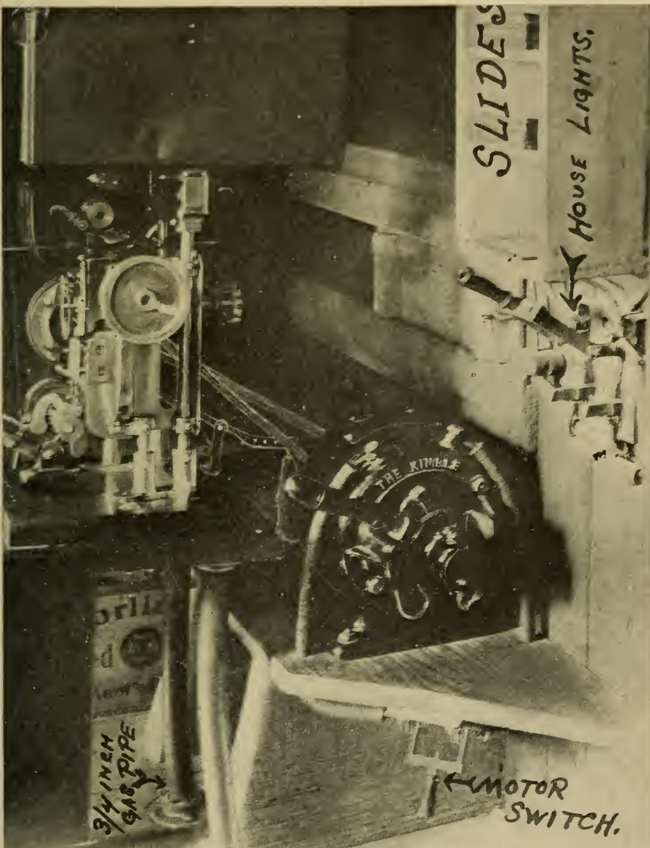


Fig. 150.

in too close contact with the film when changing reels. This would probably be condemned by many inspectors, though there is very slight chance of any spark from a motor igniting film, even though the motor be running, which it would not be when threading was in progress. Still, inspectors are usually something more than ultra-conservative, and they would most likely object to a motor located thus.

The Regulation of Motor Speed is exceedingly important. The projection machine must have a speed regulation, instantly available, of from 45 to 75 turns of the crank-shaft per minute. This may be done in many ways, and if high-class results are had on the screen it certainly must be accomplished. One very excellent method is by the use of an adjustable resistance in series with the motor field. This is a device known as a field

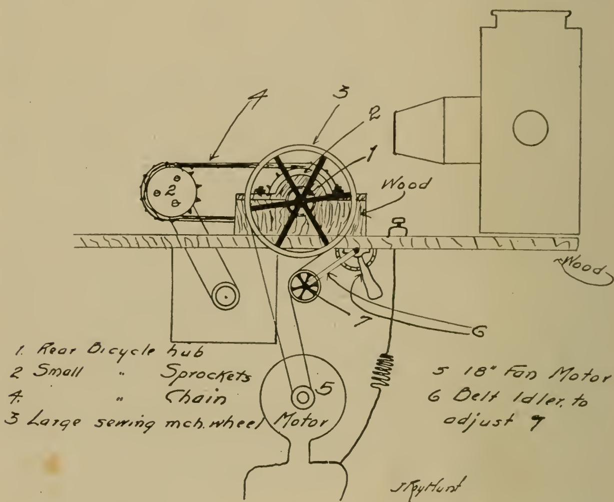


Fig. 151.

rheostat. They may be had of any large electrical supply house, but may have to be made to order to fit your requirements. The field rheostat, if used, should be located immediately in front of the operator and within comfortable reach of his hand. It is to him what the throttle is to the locomotive engineer. Speed regulation may be also had through mechanical means. It is accomplished by means of belt-slip—by giving the machine drive-belt variable tension.

Fig. 151 shows one excellent plan for doing this. The sketch is self-explanatory. Fig. 152 shows another plan which is not so good for the reason that it slackens the motor speed, which is likely to induce brush sparking, as well as possibly other more serious troubles in the motor. This objection might be overcome by running the motor belt loose enough to slip. The sketch shows a brake acting on a wheel on the countershaft from which the machine is driven, for machine speed regulation.

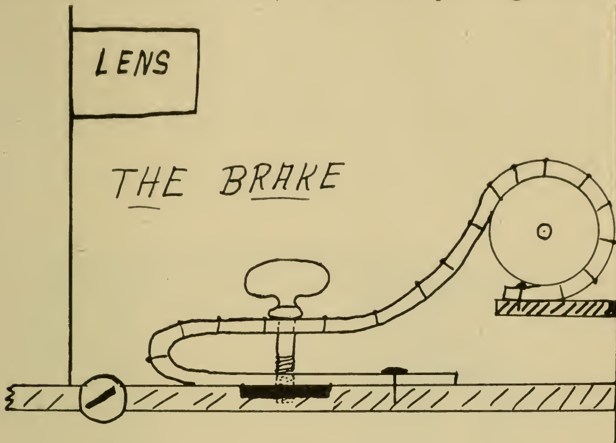


Fig. 152.

There is still another excellent plan, which is set forth clearly in Fig. 153. Cone pulleys and a belt shifter constitute the accessories and the idea is, perhaps, superior to any other scheme I have seen, except variable field resistance, for governing motor speed, though the plan set forth in Fig. 151 is also excellent.

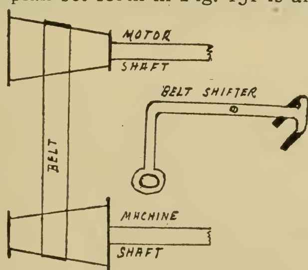


Fig. 153.

A variation of the cone pulley plan is a metal wheel about six inches in diameter, having a flat face upon which runs a small pulley having a leather or fiber face. This small pulley is arranged to be shifted toward either the rim or center of the larger wheel to which it is tightly held, thus changing its speed.

REWINDERS AND REWINDING

This is a subject of great importance, since an immense amount of damage is done films in rewinding. There are a number of excellent rewinders on the market, but I would strongly advise that the rewinder, whatever kind it may be, be motor driven. Nearly all manufacturers of projection machines put out one or more designs of rewinder, and one or two companies confine their work to rewinders alone.

One excellent rewinder is illustrated in Fig. 154, in which the two standards of the rewinder are placed facing each other,

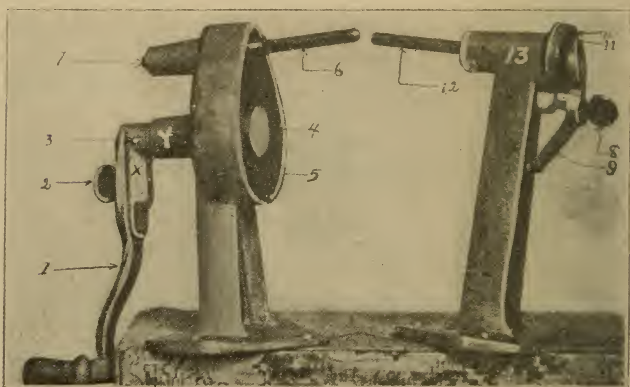


Fig. 154.

instead of as they really set when in use. This is done to show all the parts in one cut. It will be noted that the rewinder casting leans, or tilts backwards. This is in order that the reel will be held on spindle 6 and 12, Fig. 154, without being fastened thereto. Crank 1 is removed by taking out wing-nut 2, and the whole crank and its base casting may be removed from spindle 3 by driving out pin 4, thus allowing the attachment of a belt wheel for motor drive. Spindle 12 carries the reel which is being rewound from. Casting 9 bears at one end on main casting 13, and on steel washer 10 at the other end, being held by wing-nut 8. Between washer 10 and hub of main casting 13 is leather washer 11, both leather washer 10 and steel washer 11 being held to shaft 12 by means of a screw in the end of the shaft. The operation of devices is as follows: When shaft 4 and gear 5 are shoved in so that the casting of crank X is against hub Y, then the cogs of gear 5 engages with the cogs of the pinion on shaft 6, and the reel held by shaft 6 is revolved. When, however, crank 1 is pulled outward, gear 5 recedes further into the casing, and thus disengages from the pinion on shaft 6. In rewinding, tension is supplied to the reel on spindle 12 by tightening wing-nut 8, which compresses the top end of casting 9 against steel washer 10, thus compressing leather washer 11 between steel washer 10, and main frame casting 13. Shaft 12 will revolve easy or hard, according to the amount of compression supplied by wing-nut 8. This feature is of very large value, since it allows the attach-

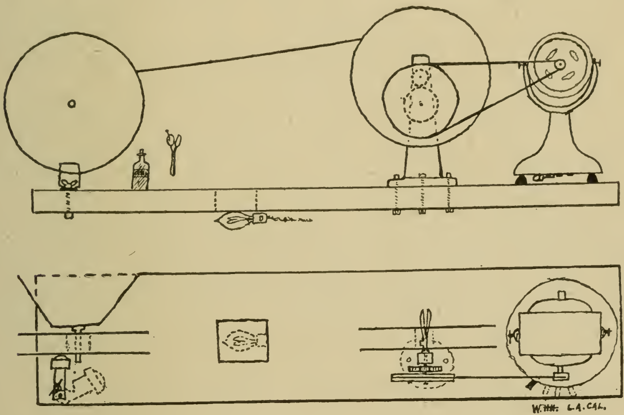


Fig. 155.

ment of a motor, and the rewinding of films, which will, if properly done, practically eliminate all damage to the film.

Some rewinders are made in one piece—that is to say, the two shafts, corresponding to 6 and 12, in Fig. 154, are mounted to one casting.

As between the one-piece and the two-piece rewinder the writer would unhesitatingly choose the two-piece. It occupies less room, and is in every way more desirable. Spiral gears are undesirable on rewinders. The straight toothed gear is the thing. Rewinder gears should be strong and substantial. They are very likely to be subjected to exceedingly heavy service. The rewinder itself should be strong and rigid and should be attached to a very firm table, or bench. A reel of film is usually anything but a well-balanced article, and when it is revolved at high speed the strain due to the unbalanced reel of film is very great. Unless the rewinder is stoutly constructed and attached to something solid, rewinding is likely to be a noisy process and the rewinder itself probably will not last long. Rewinding is usually done at high speed because it is an unpleasant task, and because time for rewinding by hand is limited. It is bad practice.

In Fig. 155 we see a small fan motor attached to a rewinder, same being designed by Mr. Wm. H. Hepburn, Los Angeles, Cal. The plan is excellent, except that there should be a variable resistance in series with the motor field to enable the operator to change the motor speed. It will be noted that in the table, or bench, is a small square of plate glass on which to make patches, with an incandescent globe beneath. This, too, is excellent, but the globe need not exceed 4 c.p. and the glass should be frosted on its lower surface by grinding with fine emery cloth.

The advantages of motor driven rewind are several. They may be enumerated as follows: (a) Unless there be patches or repairs to make, the motor can be started on slow speed, sufficient tension applied to the reel being wound from to cause the film to wind snugly, and the motor left to complete the job. An ingenious man can easily rig some scheme to automatically stop the motor when the film is all rewound. (b) It relieves the operator from considerable rather disagreeable labor. (c) It does away with the pernicious practice of "pulling down," since the motor will not mind the additional labor of rewinding against tension sufficient to wind the film tightly. (d) It does away with rewinding at top speed, with consequent liability to tear the film at any time, as well as the disturbing of the audience with noise.

Pulling Down. Pulling down consists in holding one reel stationary while the other is revolved, thus tightening the film roll. It is the cause of nine-tenths of the rainmarks in film. It causes the entire roll of film to slip on itself under considerable pressure. This naturally causes its surface to become scratched more or less—usually more. Rainmarks are nothing but scratches, in either the emulsion or the celluloid, which have filled with dirt. Were it not for the practice of pulling down in rewinding there would be very little, if any rainmarks in film, except near the ends where the machine take-up itself scratches the film to some extent. The modern projection mechanism does not injure the film in any manner, except its sprocket holes. In its passage through the machine there is no part of the film touched except its margin; therefore, no injury can possibly be done which will show on the screen. All such injury is caused in the machine take-up, or by pulling down when rewinding—nine-tenths of it being the latter. It is readily seen, therefore, that anything tending to decrease this damage is of great value.

The Stereopticon

THE DISSOLVER.

THE lamps of a dissolver should each one be connected just as though the other one did not exist. Fig. 156 illustrates the method of connecting dissolver lamps. 1 is the main switch and fuse in operating room cabinet. 2-2 are cutout blocks and fuses. 3-3 are the operating switches—one on each circuit. 4-4 are the rheostats—one on each circuit. 5-5 are the dissolver lamps. The dotted rheostat outline will be explained further on.

Where a combined projection machine and dissolver is used, the machine lamphouse shoving over to supply illuminant for lower dissolver lens, a condition usually arises which requires special treatment. Ordinarily the projection arc carries much higher amperage than is desirable for use on the dissolver lamps. Either the upper lamp of the dissolver must be supplied with equal amperage or else the lower lamp be cut down, since low amperage on one dissolver lamp and high on the other would ruin the dissolving effect. The low amperage being more desirable for the dissolver it is best to cut down on the lower arc. Referring to Fig. 156, let us suppose the upper rheostat to be of 18 ampere capacity and the lower 35. The problem then is to insert sufficient additional resistance in series with the lower rheostat to make the total equal to that of the upper, thus securing equal amperage (18) on each lamp, and to do this in such manner that we can instantly cut in and cut out the added resistance.

It is possible to accomplish the desired result by means of an adjustable rheostat which will deliver 35 amperes when all resistance is cut out, and 18 when it is all in. This, however, is not the best way, since the rheostat would probably have to be built especially for the purpose, hence quite costly. Special apparatus usually is expensive. The better way, therefore, is to insert an additional rheostat, as indicated by dotted outline in Fig. 156, of such resistance that the two combined will equal the upper rheostat, placing a single-pole, single-throw knife switch at X. A glance will show that when switch X is open the current must, in addition to the lower rheostat, traverse the resistance of the rheostat indicated by the dotted line outline. When switch X is closed the added resistance is cut out.

Where a combined machine and dissolver is used on A. C., with an operating room transformer (economizer—inductor, etc.), it is possible to operate both lamps of the dissolver from the one transformer, though it is a rather difficult thing to handle the light, also it is somewhat uncertain. Unless handled

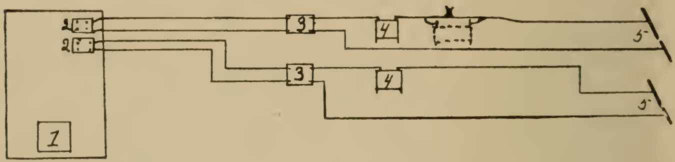


Fig. 156.

very carefully the lamps will go out. This may be done in several ways, one of which is illustrated in Fig. 157. 1 is the transformer and 2 is a double-throw, single-pole knife switch. When this switch is thrown over towards the lamps the upper lamp is cut out, though its lower carbon and carbon-arm is still "alive," unless an additional single pole switch be installed at X. When the switch is thrown the opposite way the current must pass through both arcs. It is then necessary to freeze the carbons of one lamp while the arc is struck on the other, after which open the carbons of the second lamp. It can be, and is

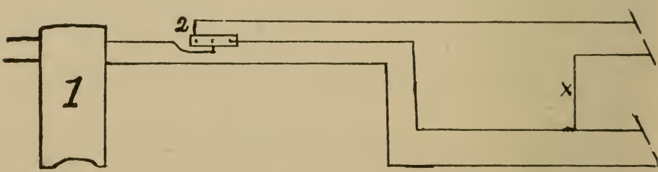


Fig. 157.

done, but, as I have said, it is very difficult to handle the arcs. The same thing can be done with rheostats also, though there is ordinarily no reason for burning the arc in series with rheostatic resistance. By the connection shown in Fig. 157, the resistance of the additional arc operates very materially to decrease the amperage.

It is quite possible to construct a home-made dissolver shutter which will give just as good results as any. Excellent dissolver shutters may now be had, however, that are not very expensive. A thin board five inches wide, pointed at one end and notched at the other, of the exact length so that the bottom of the notch will be at the center of one lens when the point at the other end is at the center of the other lens, when held upright between the two lenses, will serve every purpose. Make the notch so that its sides will be at right angles to each other, and the point end the same. Attach the board to a suitable lever so that it may be moved up and down, alternately covering each lens. A toothed, side-swinging shutter will serve the same purpose. In Fig. 158 two types of home-made dissolver shutters are illustrated. The main thing is to get them so set in relation to the

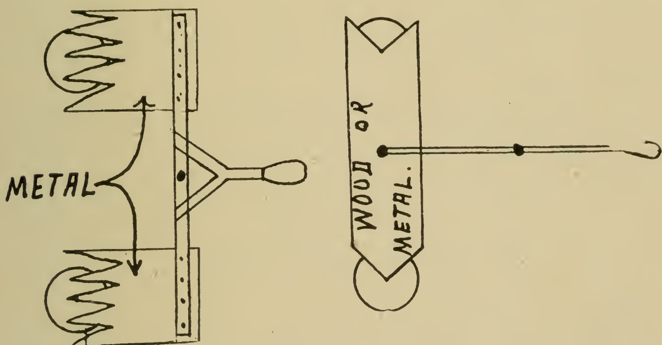


Fig. 158.

lenses that both will be half open at exactly the same time. The swinging shutter may be made of metal, as also may the other.

The stereopticon or dissolver may readily be rigged with home-made color wheels, so that colored lights may be thrown on the stage. Take off one side, of an old reel, leaving the hub attached to the other side. Place the two sides together, with the hub on the outside. Drill four small holes equi-distant from each other around the rim, and close to its edge; these to receive four small stove bolts. Cover three of the openings in the reel-sides with colored gelatine (to be had from any supply dealer), leaving one hole open. Clamp the sides together with the bolts and attach, by means of a spindle, to the wall, so that the openings come successively in front of the lens when the wheel is revolved. The open hole will allow of projection of white light and of the stereo picture as usual.

Matched Lenses.—Your dissolver lenses must be matched so that they project the same size picture, and they must be set so that the pictures register precisely—that is to say, occupy the same space on the screen. This is accomplished by setting the lower lens so that the picture comes where you want it, and adjusting the upper to match. Do this with both stereo lamps burning. The best way to test the lenses is to light both lamps and place an ordinary song slide in one carrier, say the upper one. Project it, and measure the exact width of the picture. Now place the *same slide* in the lower carrier and project it, measuring it also. The two should be the same, though a difference of one inch may be allowed. The reason for using the same slide for both projections is that if two slides were used, there might be a slight variation in the width of their mats, and this would render the results of the test of no value whatever. It might even cause you to reject two perfectly matched lenses.

The slide carriers must be so adjusted that the picture is level on the screen. This is done by raising or lowering one side of the carrier, blocking it in place with some non-inflamable substance, first, however, being sure that the machine itself, as a whole, sets perfectly level. The slide carrier should set as close to the condenser as possible. If your picture, which has been all right, suddenly registers too far over on the screen, one way or the other, it is likely the slide carrier has slipped sidewise.

There are quite a number of patent slide carriers for single stereopticons, for which a dissolving effect is claimed. The claim is not well founded. A dissolving effect with one lens is an impossibility. The best carrier I know of, and the one coming nearest to a dissolving effect, is the "Ingento" carrier, made by a well-known Chicago manufacturer. This carrier I can heartily recommend. It is well made, comes in wood or metal, and, rightly handled, produces an effect as nearly dissolving as can be had with a single lamp machine. It is for use with single stereo only. The ordinary two-compartment metal or wood carrier is too well known to need comment, except to say that a small handle screwed to its end on the operating side will be found more convenient than reaching over to shove it back towards you; also a metal mat should be permanently attached, of such size as to just allow the light to cover the screen or stage. You may then throw a flood of white light, if desired, without covering the whole front wall of the auditorium with light. If the stereo is not used the slide carrier had better be removed since it cuts off a little of the light.

The stereo picture should be clear and absolutely evenly illuminated all over. A great many operators do not pay sufficient attention to their stereo projection, and continually allow the corners of the picture to be yellow. There is no excuse for this, except where a very long focal length, half-size lens, is employed, or where a quarter size lens of more than 10 inch e.f. is used, in which case it is not always possible to avoid yellow corners. But where a combined stereo and moving picture machine is used, it will frequently be found necessary to move the lamp forward or back slightly, in relation to the condenser, when shoving over to the stereo picture. A cracked condenser will show badly in the stereo picture, but it will not show at all in the moving picture. This is due to the fact that the slide is close to the condenser in one case, while the film is away from it by from 12 to 18 inches in the other case.

The reason that a projection lens, to give a picture of the same width as the moving picture at a given distance, is of very much longer focal length than the moving picture lens, lies in the fact that in one case, the aperture (slide mat) is 3 inches by 2¾ inches, whereas in the other case, it is approximately 11-16 by 15-16 of an inch.

STEREOPTICON SLIDES

A Stereopticon Slide consists of two pieces of thin glass, 3¾ x 4 inches, bound together with gummed paper. Between these glasses is a paper mask which outlines the photograph, and is called a mat.

One side of one of these glasses bears a photographic emulsion, upon which has been printed a positive photograph 3¾ x 4 inches in size, but which is reduced by the paper mat to about 3 x 2¾ inches. However, this latter size may and does vary widely, according to the mat used. The photograph may not be, but usually is colored by the painting, by hand, of the photograph, with water colors. The second glass is just a clear, plain piece of thin glass, called a cover glass. Its only purpose is to protect the photograph from getting scratched, or otherwise injured.

It will be observed that there are usually some words, ornamental design, or figures printed on one side of the mat, and that this side of the mat is usually, though not always, red, white or some other color. This is what is called the "mat side" of the slide. Fig. 160 shows the "mat side" of a slide. The other side shown in Fig. 159. The slide must be placed in a slide carrier, the latter being *located as closely as possible to the front surface of the condenser, in an inverted position, and with the mat side towards the light.* If the other side of the slide is placed towards the light, then all reading matter thereon, such as a sign on a building, or anything of that nature, will read backwards.

The essential points in the handling of slides are: (a) *Keep them clean.* It must be remembered that every finger mark,

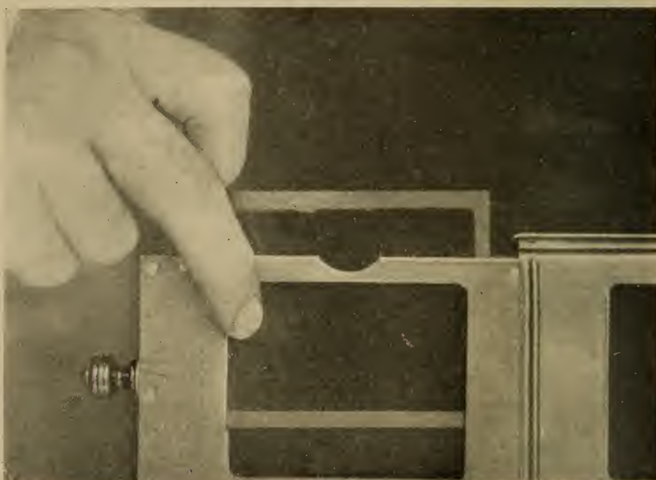


Fig. 159.

every spot of dust, bit of oil or anything of that kind on the slide, *will show on the screen,* particularly if it happens to be on a clear place, such as a sky. I have lived a good many years, but I have never yet seen a finger print in the sky, and I don't really believe they belong there, or look natural when placed there. Often I have sat in a theater and watched a beautiful stereopticon scene utterly ruined by the prints of an operator's dirty fingers, showing on the screen. *By all means keep your slides clean.* Unless you do, the result on the screen will not be at all creditable to you. Slides may be cleaned by breathing on them when they are cold, polishing quickly afterward, or by washing with wood alcohol and polishing.

(b) Perfect steadiness of the scene on the screen. There is usually no lack of steadiness when a dissolver is used, but when using a single lamp with a double slide carrier, four operators out of five will move the carrier more or less in the process of taking out, or putting in a slide. This, of course, causes the slide in the other compartment of the carrier to move, and as it is being projected at the time, it follows that the picture on the screen also moves. When, for instance, one is looking at the projection of the picture of a six-story brick building, and the mas-

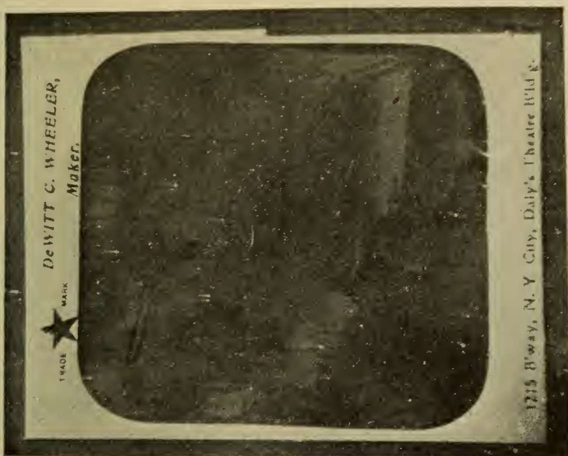


Fig. 160.

sive structure suddenly jumps up in the air a couple of feet, the effect is utterly ridiculous; therefore, when using a double carrier, be very careful when putting in and taking out the slides, not to move the carrier. This, like many other things, is easy of accomplishment if you know how. There is a right way to do everything, including the putting in and taking out of the slides from the carrier. Grasp the slide, by the upper corner nearest you, between the thumb and the forefinger. Insert it in the carrier and as it drops down catch it with the large finger of the same hand. Hold the finger against the slide and the edge of the bar of carrier, and ease slide down into position.

In Fig. 159, the correct method of taking out, or putting in slides is illustrated. The slide is grasped at its upper corner between the thumb and forefinger. The rest is readily understood from the illustration. It may be necessary to moisten the finger slightly in order to raise the slide in taking it out. By this method the carrier is not moved, and the finger does not touch the surface of the slide at all—that is to say, it only touches the slide on the surface which is covered by the mat; hence any mark made will not show on the screen.

Fig. 160 is the photograph of the mat side of a slide. You will observe in the lower left-hand corner the trade-mark, in the form of a star. In this particular song slide the star is located in the lower left-hand corner of the slide, which, when the slide is inverted and ready to be put in the carrier, will be in the upper right-hand corner. This star will, or should, appear in the same corner of all slides of this particular song, though in another song it might appear in one of the other corners. But the point is, it will, or should, always appear in the same corner of all song slides of any one song; hence in laying your song slides out for use, you merely pile slides, mat side up, with the trade-mark of all slides in the same position. This, however, cannot be absolutely depended upon, and should be checked up by the operator after piling the slides, since sometimes a mistake is made in binding up a set of slides, and one of the marks may be in the wrong corner.

There is no excuse whatever for an operator getting a slide in the carrier wrong side up.

Such a thing can only result from rank carelessness or inexperience. The operator who knows his business proceeds as follows: On receipt of a set of song slides, he first cleans them thoroughly. He then lays them in order, mat side down, beginning with the title and, 1, 2, 3, 4, 5, etc., until the chorus slide is reached, being sure that the trade-mark of all slides is in the same corner. He now turns the whole pile over and runs through them, glancing at scenes to check up the trade-mark, and to see that the tops of all slides are in the same position. He then lays the pile of slides on the machine table with the *top* of the scenes towards the *lamphouse.* In running them he picks each slide up by the right-hand corner nearest to him. He will thus be grasping the lower left-hand corner of the slide, which will be the upper right-hand corner as it goes into the carrier in an inverted position. In removing the slide from the carrier, he will lay it down with what was the top edge of the slide, as it stood in the carrier, towards the lamphouse. Follow the directions through carefully and you will discover that he has simply turned the slide over in the process, and as he takes them out, one by one, and thus lays them down he will have their order exactly reversed in relation to the way they originally laid, so that the title will be on the bottom, and the top of the slide away from the lamphouse. Under these conditions, when a song is finished all you have to do is to turn the whole pile over and they are ready to run again.

The operator who follows these directions closely will never get a slide in bottom side up. In a short time the whole thing becomes an automatic performance, and he would no more dream of picking up a slide and putting it in the carrier and taking it out and laying it down in any other way than as before indicated, than he would think of putting a spoonful of food in his ear, instead of his mouth. The trade-mark spoken of is not placed on some makes of slides, though nearly all standard makers thus mark their product. Sometimes the trade-mark is a star, as in the case of the De Witt Wheeler slides, and sometimes it is a dot, a little circle, or a figure. In cases where there are no trade-marks on slides it is well for the operator to have on hand a box of tiny gummed price labels, such as are made by the Dennison Mfg. Co. They can be had in circular form with red outline as small as ¼-inch in diameter. With them the operator can number the slides himself.

In event a slide becomes cracked, it may be made as good as new if the crack is in the cover-glass—remembering that the cover-glass is always on the mat side of a slide. In that event all one has to do is remove the broken cover-glass and put in a perfectly clean new one; re-binding the slide as it was before. If, however, the crack is in the photograph glass it is past remedying.

It is quite possible and practical to make slides to convey various messages to the audience, by writing on gelatine, with a typewriter or with a pen and ink, and binding it up, with a mat, between the two cover glasses. The same thing can be done by coating cover glass, which have previously been perfectly clean, with a thin solution of gum arabic, upon which, when dry, one can write with a pen and ink. Still another way is by using frosted glass and Higgins' black drawing ink, which can be removed with nitric acid and water. In fact, there are a dozen or more schemes, each of which has its advocates, for making reading slides. Many use clear glass and white or India ink, which is fairly satisfactory. Suitable white ink can be procured from any first-class supply dealer. If the chorus of a song is missing the chorus may be written on gelatine with a typewriter, or a pen and ink, and bound up in the regular way. In conjunction with the foregoing, see "Dissolving Stereopticon," page 375.

THE SPOTLIGHT

The operator is frequently called upon to operate a spotlight. By this I do not refer to the ordinary stereopticon spot by means of a hole cut in a metal slide, but the regular spotlight such as is shown in Fig. 161.

This apparatus consists of a lamphouse, lamp and one plano-convex lens; the inner lamp being so mounted that it may be instantly pulled back or shoved ahead to increase the spot of light or decrease it. The lamphouse is mounted on an upright staff which usually fits inside a hollow upright staff at the base of which is the rheostat, and on which is mounted the operating switch. Spotlight rheostats usually deliver from twelve to fifteen amperes. In ordering a spotlight it is necessary to give voltage of current and distance, approximately, from operating room to stage. If D. C. is used, the upper carbon must be connected to the positive wire (see page 224).

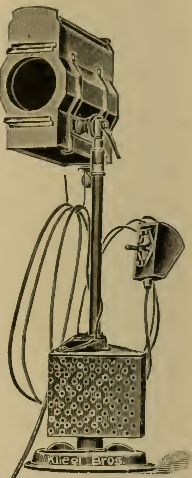


Fig. 161.

The spot should be perfectly round and free from ghost, though it will be found to be impossible to eliminate some color at its outer edges. The roundness of the spot, as well as its freedom from ghost will depend very largely on how the carbons are set. For D. C. set them about the same as for projection arc, but vary the advancement of the upper carbon tip in relation to the lower, as well as the angle of the lamp until best results are obtained. Use half-inch cored carbon above and three-eighth inch below, if you can get them. You will not be able to get the best possible results with D. C. by using two ⅝ carbons, or with one ⅝ and one half inch. The amperage ordinarily used is too low for such large carbons.

The hole in the operating room wall for the spotlight should be about 16 inches in diameter, or the same dimension square. A color-wheel adds much to the effect of the spotlight at times. By combining the use of a spotlight with a dissolving stereopticon, using slides in the latter made from etched pattern glass, and rough glass such as is used in windows, some very pretty effects can be produced by projecting both at once. Color-wheels may be had of any good supply dealer. Spotlight connection is usually made by using stage cable.

Fig. 162 illustrates how a spotlight may be constructed by using an ordinary motion picture machine lamphouse. The lens is mounted in carrier indicated by dotted line and instead of the lamp moving forward or back as with the regular spot-

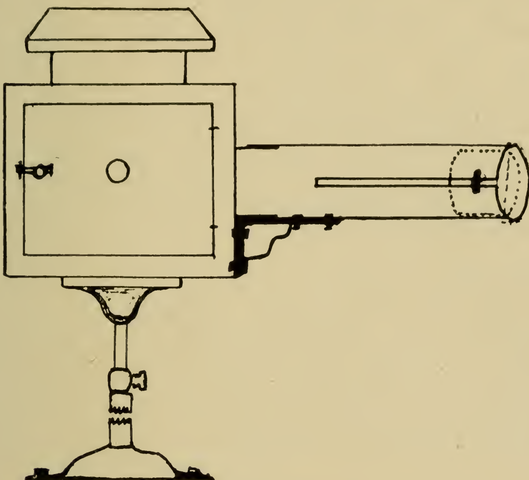


Fig. 162.

light, the lens is moved. A 4½ inch lens will answer except where a large flood at short distance is desired. For long throw, with small spot, a lens of 9 inch focal length is best.

With A. C. use half-inch cored carbons above and below. Use ordinary set, same as for projecting pictures. It will be found almost impossible to avoid a blue ghost at top of spot or a double spot on account of the double crater, when using A. C. Handling a spotlight is almost wholly a matter of prac-

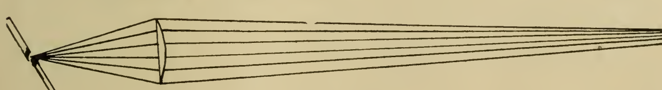


Fig. 163.

tice. The knack of it is readily acquired if one gives the matter close attention and observes results, profiting by mistakes. Fig. 163 illustrates the optical system of a spotlight.

By the use of specially made metal, paper, or glass slides, it is quite possible to make a fairly satisfactory spot with either single, or dissolving stereopticon. The slides for this purpose may be of metal, or they may consist of two cover glasses with opaque paper between them; the paper contains the hole which will form the spotlight. The hole in the slide may be of any size or shape, and the enterprising operator will have a variety of spot slides. When made of metal, one should first decide at what height from the bottom of the screen one wishes the center of the spot to be; then taking a stiff piece of cardboard, cut to stereopticon slide size and shape, place it in the slide carrier, and punch pin holes until the light through one of them strikes the curtain exactly where the center of the spot is wanted. You can then use this point as the center for the spot of all slides you wish to make.

Bell Wiring

THE electric bell and annunciator play quite an important part in the scheme of things in a theater. The installation of a single bell is a very simple matter—so simple indeed that a child might successfully install one. It is illustrated in Fig. 164. After installing the bell and the push-button in the location desired, one wire is run directly from one side of the push-button to the bell. Another wire is run from the other side of the bell to one side (either one, it makes no difference), of the battery, and another wire is run from the other side of the battery to the other side of the push-button. This completes the installation. For a single bell one battery alone, or two batteries in series may be used. By series I mean two batteries, with the carbon of one battery connected to the zinc of the other battery by means of a short wire. The effect of two batteries is to cause the bell to ring louder. Two batteries in series will not last twice as long as will one working alone.

The ordinary practice in moving pictures theaters is to use either bells, buzzers, or small, low candle power lamps for signaling to the operating room, piano player and the manager. Of the three, the lamp system, if properly installed, is the best, with the buzzer as second. The bell should never be used. A buzzer is merely an electric bell without the bell part.

What is known commercially as the dry battery is best for theater work. Wet batteries are very effective, and very cheap in operation, but they are liable to freeze up in winter and thus cause a lot of trouble. The dry battery is cheap and effective.

It is possible to renew dry batteries when they have "run-down" by taking off the cardboard casing and punching several holes in the lead casing about an inch from the top; being careful, however, not to break the carbon of the battery in the process. An ordinary nail may be used to punch the holes. Be careful also not to disturb the sealing wax around the top. Having done this, immerse the batteries in a solution of one pound of sal ammoniac to one gallon of water, and leave them for an hour or so, after which remove and stand them upside down for one hour, to allow the surplus solution to thoroughly drain out. In drain-ing the batteries, be careful that the solution does not form a contact between two binding posts, since it will carry current, and will thus short-circuit the battery and run it down rapidly. When thoroughly drained, wipe the battery dry, replace the cardboard casing and it is ready for use.

For wiring bells, No. 18 ordinary cotton covered bell wire is plenty good enough, unless the circuit be a very long one, in which case No. 16 might be used. This holds good, except in very wet places, in which case it is better to use rubber covered wires, supported with porcelain insulators.

In putting up bell wires they may be gathered together in a cable and held to the wall with a wooden cleat. They may be

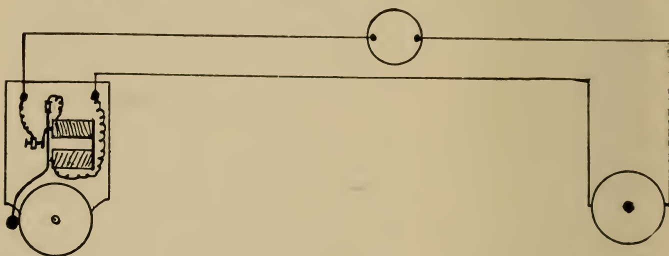


Fig. 164.

run singly around picture molding, being held thereto by small iron staples, but where this is done a staple should never be driven over two wires, since it is likely to cut through the insulation and short-circuit the bell, the battery or both. Never drive a staple over two wires. Hold each wire with its own staples. Joints in the wire should be made in the usual way (see wire splices, page 29), and should be soldered and wrapped with insulating tape. Never run your wires in a slipshod manner. Always do a job in a workmanlike way. Stretch the wires tightly and run them as they should be run. Loose, sagging wires bespeak a poor workman.

A very common practice in theaters is to use what is known as the three wire system of bell wiring. This system is the most economical in that it requires a comparatively small amount of wire for the installation of several bells. By its use any number of bells may be rung with one battery, and each bell has its own individual push-button. No push-button will ring any bell but its own. Put up the bells, buzzers, or lights and the push-button wherever you wish them to be. Use two batteries, connecting the carbon of one to the zinc of the other. Get bell wire of three different colors. The installation is illustrated in Fig. 165, in which A-A-A are bells, B-B-B push-buttons, and C a two-cell dry battery.

The reason for three colors is to avoid mistakes and confusion and to be able to find any particular wire anywhere afterwards, without tracing it clear from the battery or bell. The use of three colors of wire simplifies matters exceedingly. Suppose you get red, blue and white. You take one color, say the blue, and run it from one (either) binding post of the battery to one (either) binding post of each bell. You may run separate wires from the battery binding post to each bell or run one wire reaching all bells or you may branch off to a bell at any point. Next take another

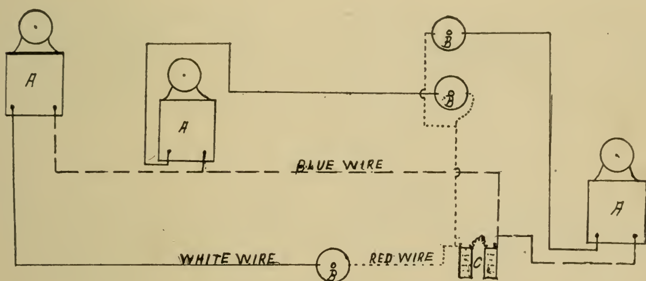


Fig. 165.

color (red, for instance), and run from the other battery binding post to one (either) side of each push button. You now have one side of the battery connected to one side of each bell and the other side of the battery connected to one side of each push button. You next, with the remaining color (white) wire, connect the remaining side of each push button with the remaining side of the bell it is to ring, and the job is done. The blue wire (blue in this case) is called the common bell wire, the red wire is called the push button wire and the whites are called the individual wires. It is these latter wires which determine which bell a button will ring and you may cause a button to ring a different bell by simply changing the individual wire to that bell. Fig. 165 shows a plan of this system. In running your wires they may be, except as before noted, simply attached to the woodwork with small staples, but you should never run two wires under one staple, since if you drive the staple a trifle tight you may form a short circuit through the iron of the staple.

Then, too, if a wire is in a place where it will swing a little the insulation is likely to wear through, thus forming a short circuit even though not clamped tightly by the staple. A short circuit may cause your bell to ring all the time or not ring at all, according to its location. If on the two wires leading to the push button the bell will ring continuously until the battery is worn out. If on the wire running from bell to battery and the wire running from button to bell the bell will not ring at all. Several wires may be run together in a bunch by using wood cleats. An additional bell or buzzer may be installed at any time as follows: Test the bell and install it and its push button wherever you want them to be. Now with a piece of first color wire connect one

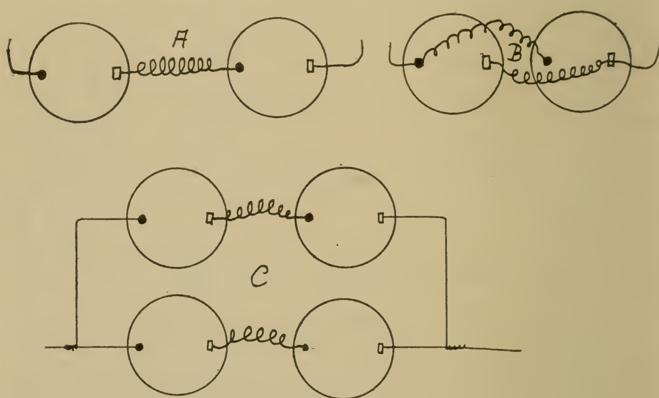


Fig. 166.

binding post of the bell with the first color wire already in use wherever you can find it. With a piece of second color wire connect one side of the push button with a second color wire wherever you can find one. Understand you can just tap on to these wires at any point you can locate one of proper color. Now connect the remaining side of the button with the remaining side of the bell with third color wire and the job is done. The rules governing this system of wiring are as follows: One side of the battery must be connected with one side of each bell by first colored wire. The other side of the battery must be connected to one side of each push button with second color wire and the remaining side of each button must be connected with the remaining side of the bell it is to ring with third color wire.

The various battery combinations are illustrated in Fig. 166. A increases the voltage without affecting the amperage. B increases amperage without affecting voltage. C increases amperage and voltage. A is series, B multiple and C is a multiple of series.

FIRE ALARM SYSTEM

In Fig. 167, we see two fire bells, one located, let us suppose, in the manager's office, and the other on the stage, or at any other suitable point. We also see an ordinary push button at A, and a form of contact more suitable to such work at B, either of which will ring both bells. As many of these may be attached as desired, locating them at any point in the house. Attach one

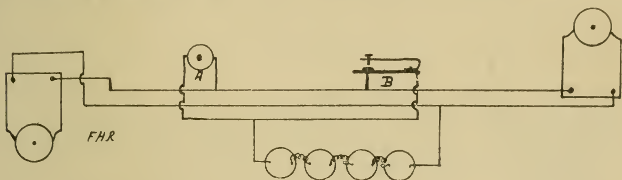


Fig. 167.

side of the button to upper wire and the other side to the battery wire, as shown. In the illustration we see four batteries connected in series. This being a fire alarm system, it is desired that the bell or buzzers ring very loudly, hence several batteries are connected in series. Employees should be made to understand that it will mean instant dismissal to ring these bells, except in case of actual necessity. The system can be arranged for any number of bells, from one to a dozen, and there can be as many push buttons as desired.

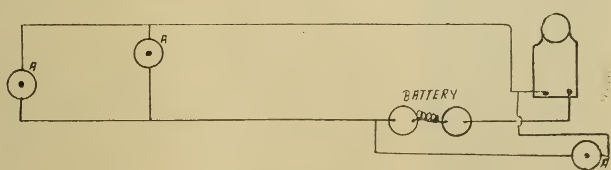


Fig. 168.

Fig. 168 illustrates the method of connecting a bell so that it may be rung by more than one button. By this plan as many buttons may be installed as desired, any one of which will ring the bell, provided the wire from push-button to battery wire be not connected between battery and bell. A-A-A are push-buttons.

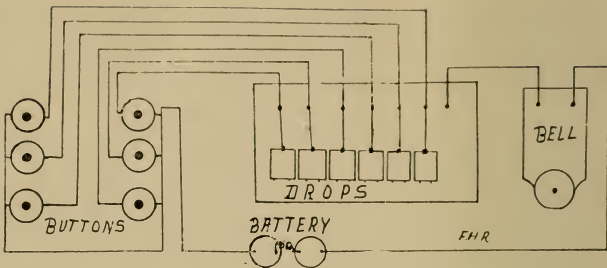


Fig. 169.

In Fig. 169 we see the method of wiring an ordinary annunciator. The plan is too plain to require explanation. The buttons may, of course, be located anywhere in the building, and are ordinarily widely separated.

ELECTRIC PROGRAM BOARD.

I reproduce herewith a cut from the Bioscope, an excellent English publication, which is the best I have seen to date. I think the action will be plain when you trace the contacts in Fig. 170 through. I have changed the sketch to the extent of making one wire heavier than the other, in order to enable you to more readily trace out the electrical action.

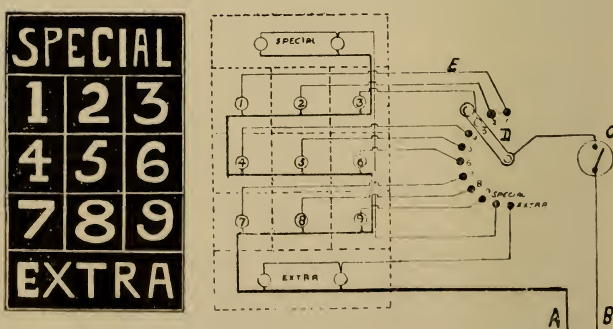


Fig. 170.

Wire A, we may call the permanent connection. As you will observe, it connects directly to one side of all the lamps. Wire B connects through switch C and movable arm D, to the various contacts 1, 2, 3, 4, etc. Now suppose we place arm D on contact 1. You will observe that the current will flow through wire E, through lamp 1, and thence back on through the other wire, and that no other lamp will be affected. If we move the arm to contact 6, then only lamp 6 will be lighted. Such a contact is simple, entirely practical, and as I have said, is the best plan I have seen. It is also quite possible to substitute single pole, single throw knife switches for contacts 1, 2, 3, 4, etc., connecting wire B to one side of all these switches. The switches or the contacts should be located at the most convenient point, either on the stage, by the side of the musician or in the operating room. The transparency can be so made that only the figure or name actually illuminated

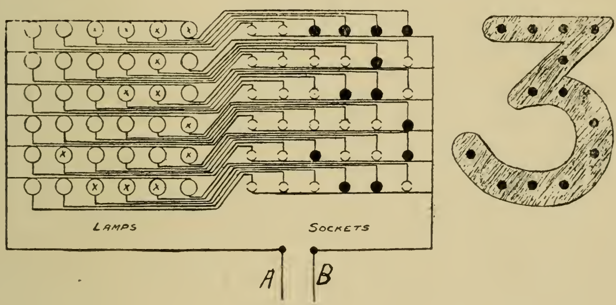


Fig. 171.

will be visible. This can be done by covering the whole front of the board with ground glass, on which are the figures, or names blocked out in black, as shown in the illustration, each lamp, however, being contained in a light tight compartment of its own. Different colors may be obtained, if desired, by covering the various characters with light shades of gelatine or using colored globes.

In practice, I would by all means, advise a double pole single-throw switch at AB, rather than the single pole knife switch at C. The same article contains a description and an illustration of another excellent method of outlining figures, which, with apologies to The Bioscope, I herewith reproduce, with a few additions to make it plainer.

In Fig. 171 a battery of 36 lamps is arranged in the form of a square, with 6 lamps either way. One wire (wire A, in the sketch) is connected directly to one side of each lamp. A board is now made, containing 36 sockets, arranged in a square, with 6 sockets each way, the same as are the lamps. This board may be placed in any convenient location, either near the lamps or removed at a distance from them, as may be most convenient; but in any event, the other side of each one of the lamp sockets must be connected to one side of each socket as shown. We now connect the other side of each one of these sockets to wire B, as per the illustration, installing a double pole, single throw switch, at any convenient point in wires A, B. Both sides of the socket are now alive, one directly from wire B, and the other by way of the lamps through wire A. It will, therefore, be readily seen that if an ordinary plug fuse be screwed into any one socket, the lamp connected to that socket by cross wire will immediately be lighted, and will burn until the plug is removed. Now suppose we wish to form a figure 3. It would be only necessary to insert the plugs in the sockets indicated, in order to outline the figure 3 on the board, wherever it might be placed. In using such a plug board, it is advisable to have a pattern of the various figures and letters it is desired to use. Patterns may be made of cardboard.

Where printed programmes are used, it is quite possible to install such a board at the side of the stage, with the plug board and the switch controlling the supply wires located in the operating room, within convenient reach of the operator. He can then plug in any desired number and illuminate the same by merely throwing in the switch, i. e.: Supposing he is running reel 2, the next being, of course, reel 3, which is described on the programme under that number. He prepares Fig. 3 by placing the plugs in position in the board, and as reel 2 is finished, he throws in the switch, illuminating Fig. 3, thus allowing the audience to look at the programme while the next reel is being threaded, or during the interval between the two reels. Where only one number is to be used the board can be made very small, and it is not necessary to use more than two or three c.p. lamps, same being of the proper voltage of course. Such a board can be used to decided advantage in many ways. The lamps, if used within the auditorium, should be frosted, or else heavily colored. It is possible to so connect the various figures through batteries of switches that the plug arrangement is unnecessary. This is more costly, and the plug serves every purpose. It is quite possible to substitute single pole, single throw switches, or ordinary snap switches in place of the plugs. The arrangement shown in Fig. 171 is much the best for programme announcements.

General House Equipment

HEAT AND VENTILATION

As to the heating of the moving picture theater, the circumstances, shapes, sizes, etc., of theaters, are diversified, and cover such a wide range that it would be practically impossible for me to give much specific data of value without consuming literally hundreds of pages of this book. The subject is worthy of a special book by itself. It may be said in general, however, that while the combined heating and ventilating system has its advocates, still there is serious objection to the scheme; not the least of which lies in the fact that if anything goes wrong with one, it necessarily affects the other. Broadly speaking, there are two systems of heating, one of which is the warming of the air before it enters the auditorium, the other is the warming of the air after it has entered. The combined system of heating and ventilation presumes the blowing of air into the auditorium through a series of steam or hot water pipes, by which it is warmed in winter, or a series of cold water pipes, by which it is cooled in summer. The best practice presumes the inlets into the auditorium to be about six feet above the floor and the outlets in or near the ceiling. This plan has the objection that the air, being warm, immediately upon entering rises, passing out at the ceiling ventilators without disturbing or changing the bed of foul air next the floor, which the audience is continually breathing, since that air is colder and cold air does not rise. On the other hand, there is serious objection to the heated air being driven up through floor radiators, by reason of the fact that more or less unpleasant and even dangerous draughts are thus created.

The ideal system for large theaters seems to be one by which cold air is driven in through inlets about six feet above the floor, the actual heating being done by radiators conveniently located in the auditorium. Cold air is heavier than warm air, hence the cool air immediately upon entering settles to the floor, mingles with the vitiated atmosphere, is heated and rises, passing out through the ceiling ventilators. In this connection let it be clearly understood that there is a vast difference between ventilation and a mere stirring up of the air by wall fans. As a matter of fact wall fans, or ceiling fans, unless set in an opening by means which they pump air into or out of the auditorium, have nothing whatever to do with ventilation. Ventilation is the process of constantly changing the air in a room, substituting fresh air from that made foul by use.

For small theaters of the store room variety, ventilation can, I believe best be accomplished by blowing air in at one end of the theater, preferably the curtain end; providing an outlet at the other end, of course. To be effective the movement of air must be fairly rapid. It should be remembered that in summertime the air pumped into the room will be practically as warm as that already inside. It must therefore, depend for its cooling effect entirely upon the evaporation produced by rapid movement, in explanation of which I will say that anything which produces evaporation lowers temperature—hence, while the air blowing against one's face may be quite warm, still it feels cool to us, by reason of the fact that it causes a rapid evaporation of moisture from the skin.

You may perhaps have noticed that a drop of alcohol spilled on the back of your hand will, although of even temperature with the surrounding atmosphere, feel quite cold. This is by reason of the fact that it evaporates rapidly, hence lowers the temperature of the skin at its point of contact. Somewhat the same effect is produced by benzine or gasoline. This being true, it follows that if the air be driven through the room fast enough to cause evaporation of perspiration, it will not only keep the air within the theater pure, but it will also produce the sensation of coolness.

A great many schemes have been tried for cooling the air inside of theaters, but this seems to be, taking everything into consideration, the most successful, but it of course, requires fans of ample dimensions during hot summer weather. For the ordinary sized store room theater, some have tried the plan of blowing air through a maze of cold water pipes. This is fairly effective, but the fly in the ointment is its excessive cost, unless there is an unlimited supply of cold water available at very low cost. To cool the water with ice is prohibitive. However, one or two large cakes of ice each on a table properly drained, and placed at various points of the auditorium will radiate a surprising amount of cool air for quite a distance.

Taking everything into consideration, I am forced to the conclusion that a good strong current of air through the house is best, but this should not be carried to excess, as that would create danger. If the current of air be too strong, one coming it from a hot street, covered with perspiration will find the cooling off process to be too rapid and probably the cause of a severe cold. There have been numerous cases where particularly susceptible persons have contracted a cold that proved fatal, from sitting in a fan draught. Where a new theater is being built it is always advisable to consult a sanitary engineer in regard to the ventilation of the auditorium. It is a subject of too much importance to be in other than competent hands.

In this connection, let it be clearly understood that when it comes to moving air, the volume of movement will depend upon the area of the fans. This seems like a simple statement, but when you come to think of it, it really means that every increase in diameter is effective by four times, thus: A 36-inch exhaust fan will move four times the amount of air that an 18-inch fan will move, both running at the same speed. It therefore, follows that the larger fan is very much better adapted to use in theaters, from more view points than one. It will move a vastly greater amount of air at a very much lower speed, than will its smaller diametered brother. It will be found as cheap, or cheaper, in first cost, to install one large exhaust fan than two small ones of equal combined capacity. It will be found that one large fan will move a cubic yard of air cheaper than will two smaller ones, and that the upkeep cost of one large fan will be less than that of two small ones of equal combined capacity—provided that the large and small fans be of equal excellence in mechanical and electrical construction.

Don't buy cheap fans. It costs more in first outlay—considerably more—to get good fans, but *it pays in the long run,* both in money and in the saving of temper. A cheap fan is not only ineffective, but its up-keep is usually very expensive; also its useful life is short. Still worse than all this, however, is the fact that it is a continual source of annoyance, because there is usually something wrong with it about half the time, and it is generally out of commission when most needed.

While all such data is more or less vague and dependent upon circumstances, the usual allowance made for ventilation purposes—that is to say the keeping of the air pure—is 40 cubic feet of air per person per minute in theaters. This requirement is, for some unexplainable reason, reduced to 30 feet for moving picture houses. It must be carefully remembered, however, that this requirement is merely for ventilation purposes and has very little to do with the movement of air to produce coolness. A great many sets of rules are given for figuring the necessary capacity of fans to change the air in rooms of various dimensions in a given time.

I shall give you one of these rules which I have selected as the best, but you must understand that it is only approximate, and cannot be wholly relied upon, since very much will depend on the kind and type of fan used, as well as its position, and whether it has free delivery or delivers through a pipe.

In figuring the necessary size of fan to use, you must first determine the number of minutes in which the air in a given room must be changed, which is found according to the following formula: The constant in this instance being 30 cubic feet

$$\frac{\text{Length x Width x Height}}{\text{Seating capacity x Constant}}$$

of air per person, per minute for the moving picture theater, or 40 for the regular theater. For instance, supposing we have a room 25 feet wide by 80 feet long, with an 18 foot ceiling, seating capacity 200, the problem would be as follows:

$$\frac{25 \times 80 \times 18}{200 \times 30} = \frac{36{,}000}{6{,}000} = 6$$

We therefore, find that six minutes is the time in which it would be necessary to change the air in such a moving picture theater room in order to serve the purposes of adequate ventilation. The following table is taken from one of the advertising circulars from the Watson Ventilating Fan.

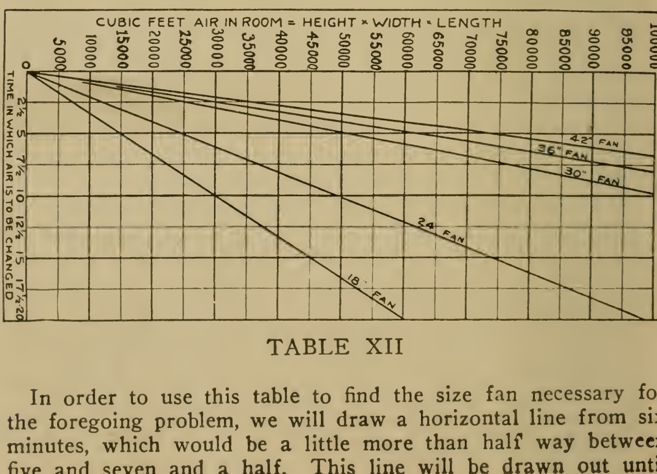


TABLE XII

In order to use this table to find the size fan necessary for the foregoing problem, we will draw a horizontal line from six minutes, which would be a little more than half way between five and seven and a half. This line will be drawn out until it crosses a line opposite 36,000, in the cubic contents column and we find that in order to secure a change of air in six minutes we must use a 24-inch fan, although it will lack a little of the requirement. To make the matter a little more clear, first find the number of minutes in which the air in the room must be changed. Next draw a horizontal line from the time until it crosses a line vertically from the cubic contents of the room, and the diagonal fan-size line nearest will indicate the necessary size of the fan.

As to the matter of heating I would not care to offer much advice, since, as I have said, the circumstances are so very different in different cases that advice which might apply in one case would probably be totally wrong in another. Stove heat should never be used; electrical heat is too costly, as is also gas, and this, in practice, restricts us to the hot air furnace, the steam, or hot water systems of heating. Which one of the three will be best in any given case must be decided by the owner or architect of the theater. A very great deal will depend, however, upon the kind of furnace installed. I would therefore, advise you to look very, very carefully into the merits of the different heating devices. The foregoing is perhaps rather meagre, but I do not feel that it is possible to go into the matter further, since, as before stated, to deal with it fully and completely would require a separate volume.

Ceiling and Wall Fans.—While, as has been said, ceiling and wall fans have nothing whatever to do with ventilation, still by reason of the movement of air producing the sensation of coolness through evaporation, they play a very important part in the theater. Judgment and care should be exercised in the location of wall fans. They should not blow directly on the audience, but should be set on shelves about six or seven feet from the floor, and set to blow straight outward, pointing in the direction which will assist rather than retard the the movement of air through the room. Ceiling fans may, of course, be located anywhere that is deemed advisable, since they blow straight down and do not ordinarily produce any large current of air.

In this connection, it is much better to have comparatively large wall fans running at slow speed, than to have small fans running at high speed. They are cheaper of operation and make less noise, modified by the fact that too large a wall fan would create too heavy an air current in one direction. What has been said of exhaust fans applies equally to wall fans. We may, however, consider 18 inches as the extreme diameter advisable to use. All fans must, of course, have intelligent care and attention. They should and must be oiled at stated periods. The bearings of electric fans run in an oil well. This does not mean, however, that they will run forever without a refilling of the wells. The oil wells should be thoroughly cleaned out and filled with fresh oil once a week in summer. There should be stated times to do this, and it should be done at that time, otherwise it will in all human probability be neglected, and this neglect will mean cut journals and trouble. The commutators of fans should be examined occasionally and both the bars and bushes kept in good condition. A good scheme with fan commutators is to let well enough alone. That is to say, if the commutator is running nicely, don't fool with it. If it is sparking badly, however, remove the brush to see if the contact is good, or to see if the commutator itself is black and dirty, or roughened, in which case, carefully clean it with double O sandpaper. Never use emery paper on a commutator, since it contains particles of steel and iron, and you will simply aggravate the trouble by smoothing it up with emery paper. The principal thing with a fan is to have regular, set times for examining, oiling and cleaning them, and to exercise good sense in caring for them.

LIGHTING THE THEATRE

I shall deal somewhat briefly with this subject, since conditions are so very different in different houses that only general information can be given. In the first place let it be understood that it is now quite possible to project a splendid picture with sufficient light in the auditorium to enable one to see dimly all over the house and clearly for some twenty feet in his immediate vicinity.

The principal objection to the dark theater lies in the opportunity afforded for improper acts, verging on immoral, or at least tending in that direction. The above-mentioned illumination fills every need in the prevention of such acts and more light is unnecessary from any point of view. It also helps the usher, and empty seats are easier to be found. It is fully as much light as is ordinarily found in the regular dramatic theaters. Most of the talk about daylight theaters is pure buncombe. There is no need for any such thing, except for outdoor work. More light than indicated above is not only totally unnecessary but is harmful in that it requires excessive current consumption to offset the daylight, without corresponding gain.

There are various ways of obtaining the desired auditorium illumination, the most popular being what is known as the "Indirect Lighting System." The amount of light required to produce a given illumination will depend largely on the color and finish (with or without gloss) of the ceiling and walls—particularly the ceiling if indirect lighting is used. Various colors reflect light about as follows—the figures indicating the percentage of the total illumination reflected:

Black, without gloss	1%
Chocolate, without gloss	5%
Dark Red, without gloss	13%
Dark Brown, without gloss	14%
Blue, without gloss	26%
Yellow, without gloss	45%
White, without gloss	75%
White, glossy	85%

In this connection the following table gives the approximate effect in illumination, produced by open 16 c.p. lights in a room having medium ceiling and wall colors and a ceiling not exceeding fifteen feet in height.

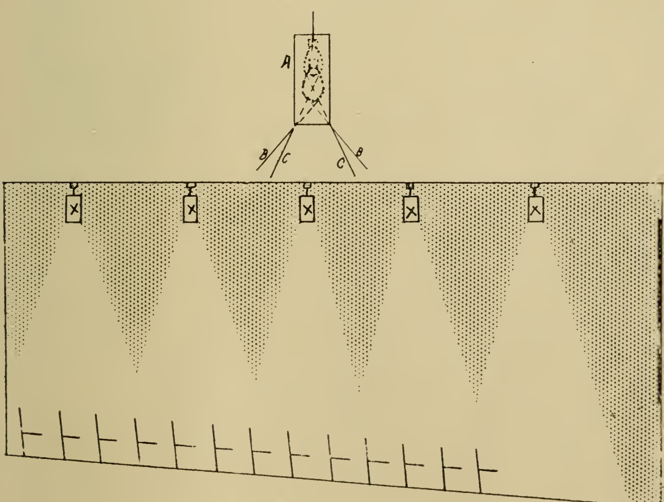


Fig. 173.

No. lamps per 100 sq. ft. of floor surface.	Approximate effect.
1.0	Dull
1.5	Medium
2.0	Good
3.0	Bright
4.0	Brilliant

Let it be quite clearly understood that the foregoing table is only approximate, and that darkening of wall and ceiling colors, or added height of ceiling will operate to rapidly cut down the illumination effect. The two most feasible methods of lighting, are as follows:

In Fig. 173 we see the first plan illustrated. At A is a detail of one of the metal shades, inside of which are suspended ordinary incandescent globes of any desired c.p. with the globe in two positions. Lines B B and C C show the effect in spread of light by raising or lowering globe in shade. The metal shade should be white inside and rather narrow and deep. The distibution of light is shown below, XXXXX being shades containing globes. The lights should be so arranged that the rays of one lamp will meet the rays of its neighbors about six feet from the floor. The plan is cheap and quite effective. Any tinner can make the shades, which may then be painted to match the walls or ceiling. The rays should not be allowed to strike the side walls of the room.

Fig. 174.

Indirect Lighting System.—What is known as the indirect lighting system consists of enclosing incandescent globes in a metal fixture, entirely closed at the bottom and entirely open at the top, so that the rays are directed upward toward the ceiling and are thence reflected downward in a diffused form.

As seen in Fig. 174, some of these fixtures are very ornamental. They may be had in black iron, bronze, brass, etc., and really add to the appearance of the room. As will be readily understood, referring to the percentage of light reflected by various colors, as set forth in the forepart of this subject, the color of the ceiling will have a great deal to do with the necessary number of lamps to be employed to secure the desired intensity of illumination. The lighter the ceiling the more light will be reflected. Where an ordinary cloth, plaster or kalsomine-coated screen is used it is not well to have the first fixture closer than twenty feet from the curtain.

Where side-wall lights are employed they should not be less than six feet from the floor, and seven is usually better. Their rays should be carefully shaded in such manner that they do not strike the eyes of the audience directly. It is very irritating in a dimly lighted room to sit for an hour looking at a picture beyond an incandescent light, the direct rays of which strike the eyes. Those with strong eyes may not notice it (though they would enjoy the exhibition better were the light removed), but any one having weak eyes surely will be seriously annoyed. Coloring such lights helps, as also does frosting them, but neither is sufficient. They should be either shaded on both the audience and screen side with a semi-opaque shade or else enclosed in a large, completely enclosed shade, colored on its sides and frosted on its bottom. But the side light is unnecessary and had better be dispensed with entirely.

Avoid placing lights around the curtain or proscenium arch. This was a very general practice a few years ago, being taken from the large theaters where such lights are placed around the proscenium arch to blind the audience and render the stage invisible while quick change of scenery is being made without lowering the front curtain. It has no right place in the motion picture theater. There is no necessity for it and it is painful to the eyes to be obliged to sit through a five or ten minute intermission staring directly at ten or twenty incandescent lights placed around the edge of the screen.

Whatever system of lighting is used it is well to have the wiring so done that a part of the lights only may be burned without seriously affecting the light distribution as a whole, merely producing less brilliancy, thus: if you have four indirect lighting fixtures, each containing four 16 c.p. globes. Now if you have each fixture wired independently you could extinguish two of them and reduce the total illumination by half, but a portion of the room would be in semi-darkness while other portions would be well lighted. If, on the other hand, you have the fixtures so wired that you can, by pulling a switch, extinguish one light in each fixture; by pulling another put out a second light in each fixture and by pulling a third and fourth extinguish the others, you could diminish your total illumination by one-fourth, one-half or three-quarters without in any manner disturbing the distribution, as a whole. The advantage of this is too obvious to require argument. The lighting should be so arranged that the operator can control at least one auditorium light circuit, thus being able, in case anything goes seriously wrong, to light the room instantly. This may be done in several ways, too patent to explain, but it should be arranged.

The aisle floors may be lighted by placing under the end chair of every fifth row of seats an 8 c.p. incandescent globe (frosted), enclosed in a small metal box, the aisle side being covered with wire netting. The wire leading thereto should come up through a small hole in the floor, the same located at the end of the metal box. Over every exit must be a light enclosed in a suitable metal box, the front of which is of red ground glass, having the letters EXIT blocked out, these letters to be not less than five inches high. The letters themselves should preferably show red. If red ground glass is not easily obtainable ordinary ground glass may be substituted and red gelatine, to be had of any exchange, placed over the letters. If ground glass is not available, ordinary glass may be easily ground with No. 1 emery cloth, using considerable pressure and an irregular, circular motion. It may even be done with a flat block of soft wood and ordinary sand.

In general it does not pay to be too economical with lights in a theater. During the intermission a dimly lighted house is gloomy and uninviting; it is, therefore, to a certain extent, depressing. Plenty of light, during intermission, pays.

Before closing this subject let me say that lamp globes decrease the total illumination by about 10%; if they be lightly ground this is increased to 30 per cent., whereas heavy frosting cuts about 45%, as also do thin opal globes. Heavy opal glass cuts about 60% and cut glass approximately 15%.

ELECTRIC METERS

For measuring electricity, it has become standard practice to use an electric meter which is now commonly known as a watt-hour meter. The principle of the watt meter is as follows: the recording dials are operated by a small motor. This motor is placed in series with the lamps, or motors, taking current through the meter. The motor is so constructed that if it were operated under a pressure of one volt with one ampere of current flowing, then it would record one watt, and if this record be kept up for one hour, then it would mean that one watt had been consumed during that period. In other words, energy would be consumed equal to one watt-hour. With this as a basis. it is not difficult to understand that if the pressure be 10 volts and the number of amperes be one, then in one hour the meter would record $10 \times 1 = 10$ watt-hours; or if the voltage be 110 and the number of amperes flowing be, let us say, five, then in one hour the meter would record $5 \times 110 = 550$ watts, or 550 watt-hours. The meaning in effect would be that 550 watts have been used for a period of one hour.

To go a little further into details: There are two general types in use, one for alternating current, which is known as an inductor meter, and one for direct current, which is commonly called a direct current meter. The direct current meter is connected in circuit as diagrammatically shown in Fig. 167. You will note by referring to this diagram that the 110 volt service mains run into and through the meter. You will also note that the armature is connected across the circuit at all times. In

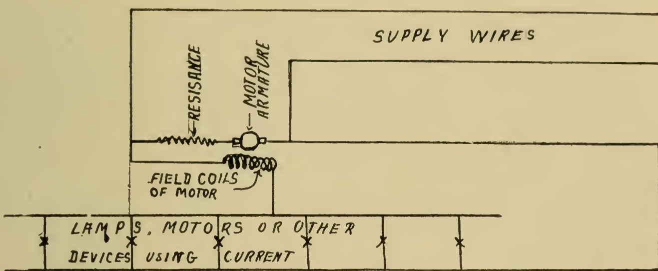


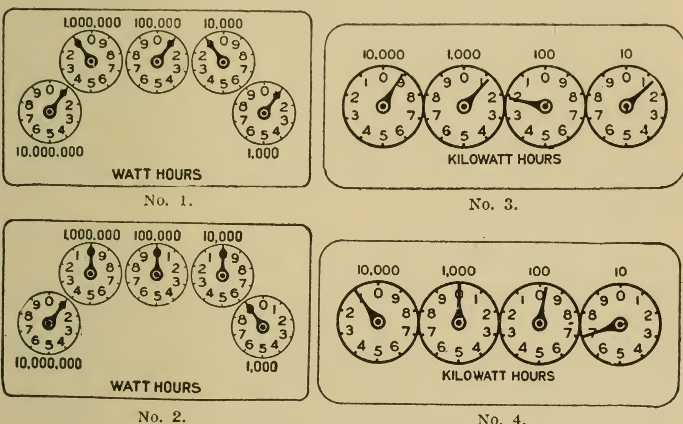
Fig. 175.

other words, that the armature circuit is always excited. However, in order to make the meter turn around just as in an ordinary meter, it is necessary that there be current in both the armature and the field circuit. Now, you will see by tracing out the sketch that unless there are some lamps, a fan motor or some other device being used on the circuit, there is no current flowing through the field coil. Therefore, there is no tendency for the motor to rotate. Just as soon, however, as a lamp is turned on, the current flows through the field coil, to the lamp and back to the other side of the circuit. This current going through the field coil in combination with the current which is already flowing through the armature circuit causes the motor to turn around at a certain speed. Since the strength of the field depends upon how much current there is in it, the more lamps you turn on, the more current there is in the field and the stronger this field. The stronger the field, the faster the motor turns; therefore, the more lights or more power you use, the faster the motor armature turns and the greater the amount of power recorded on the dial, which determines the amount you will have to pay for service.

The unit of quantity in which electricity is measured and for which bills are made is the watthour, which is merely a measuring unit, the same as the gallon is a measuring unit in measuring liquids. A watthour is one watt of electricity used for one hour, a watt being the product of one volt times one ampere. That is, if an electric circuit is so arranged that it takes one ampere of current at one volt, the amount of electric power consumed is one watt. If this is used for an hour, one watthour is consumed. Ordinarily lighting circuits for use with electric lights have a potential of about 110 volts. A 16 cp. 110 volt incandescent lamp uses, say, 50 watts; therefore, if you use one lamp for one hour, you will use 50 watthours; for 2 hours, 100 watthours, and so on. When this lamp is measured by a watthour meter, the meter will record the 50 watthours for each hour this lamp is used. The ordinary commercial unit in which electric energy is measured is the kilowatt hour, which is 100 watts for one hour or any combination which will give this amount, that is, one kilowatt hour is 1,000 watts for one hour, or it is 100 watts for ten hours. In other words, if you use one 50 watt lamp for ten hours, you pay for 500 watthours, or if you use ten lights for one hour, you pay for 500 watthours or one-half a kilowatt hour.

The so-called "direct current commutating meter," explained above, can be used on alternating current circuits. The induction meter, however, which is somewhat similar in operation to a small alternating current fan motor, is much simpler than the direct current meter, as the armature is merely a revolving aluminum disk and no commutator or brushes are necessary. This type of meter is now always used for alternating current. The adjustment of the induction meter is made similar to that of the direct current meter in that its speed depends upon the amount of current being used in the circuit to which it is attached. You therefore have the same conditions, in that, if you use one light, it runs at a certain speed and if you use ten lights, it runs ten times as fast and therefore records or registers on its dials ten times the amount of energy. In the induction meter, the rotating element or the armature consists merely of an aluminum disk in place of the coil of wire and commutator which forms the armature of the direct current meter explained above.

When attempting to read a meter, first note carefully the unit in which the dials read. On all meters used by the Edison Company, the figures above or below the dial indicate the value of one complete revolution of the pointer, therefore one division indicates one-tenth of the amount marked above or below. Note the direction of rotation of the dial pointers. Counting from the right on a watt meter, the pointers of the first, third and fifth dials rotate in the direction of the hands of a watch, whereas the pointers of the second and fourth dials move in the opposite direction. Similarly, on a kilowatt hour meter the pointers of the first and third dials move in the direction of the hands of a watch, and the pointers of the second and fourth dials move in an opposite direction. The dials must always be read from right to left, and the figures should be set down as read. Always read the figures on each dial which the pointer has last passed or has just covered.



No. 1. No. 3. No. 2. No. 4.

Facsimiles of Meter Dials.

Fig. 176.

Each dial reading depends on the reading of the one next to it on the right. Unless the one before it has completed a revolution, or passed the "o," the pointer which is being read has not completed the division on which it may appear to rest, and still indicates the last figure passed over.

Always ascertain if the meter is direct reading, that is, has no multiplying constants. Some meters are not direct reading but require that the dial reading be multiplied by a constant in order to obtain the true reading. This is for the purpose of keeping meters of various capacities uniform in size. If the constant were not used, meters of larger capacity would be much larger and heavier than those of small capacity. If the register face bears the words "multiply by ½," or "multiply by 2" etc., the actual reading should be multiplied by ½ in the first case, or doubled in the second and similarly for other constants.

Next multiply the difference between the present reading and that of the last month by the rate per kilowatt hour you are paying, and you have the amount of your bill in dollars and cents.

The accompanying facsimiles of meter dials give examples of meter readings which may actually occur in practice. For example, in No. 2, the dial at the extreme right reads 900. The second apparently indicates 0; but since the first has not completed its revolution, but indicates only 9, the second cannot have completed its division, hence the second dial indicates 9 also. The same is true of the hand of the third dial; the second being 9, has not quite completed its revolution, so that the third has not completed its division, therefore we again have 9. The same holds true of the hand of the fourth dial. The last hand (the extreme left) appears to rest on 1; but since the fourth is only 9, the last has not completed its division, and therefore indicates 0.

Putting the figures down from right to left, the total reading is 999,900. By similar reckoning the value of other indications may be obtained.

MAXIMUM DEMAND INDICATORS

Usually a consumer of electric power using a certain amount of current pays a certain price, depending on the amount of power used. But in some cases, in order that the station supplying the power may not be put under heavy load at certain periods, the price to the consumer is based on a maximum demand rate; that is, if the amount of power which they take at any time exceeds a certain amount, there is an additional charge for this extra amount of power which is taken. The Wright Demand Indicator is used to register the maximum amount of power used for five minutes or more during a certain period.

The Wright Demand Indicator consists of a U tube in which there is mercury, and when connected in circuit the electricity or current which is used passes through a coil which surrounds an air bulb on one end of the U tube. Provided the current is in excess of a certain amount, the coil gets heated from the current and expands the air in the bulb. This expansion of air on one side of the U tube causes the mercury to rise in the other side of the tube. The indicator is arranged so that the full amount of power used over a certain amount will not register unless the load is held on about 5 minutes. At the end of the month, the reading on the demand indicator is taken and if the column of mercury which has been forced into the measuring tube by the expansion of the air caused by the large amount of current used is beyond a certain amount, the station charges a certain extra amount for this heavy load which has been used for at least five minutes or more. After the reading has been taken, the indicator is opened and the tube tipped up until the mercury runs back out of the measuring tube in the U tube and the indicator is again ready to record the maximum amount of power which is used at any time during the next month.

If a customer ordinarily uses 50 amperes at 110 volts, that equals 5500 watts, or approximately 7.37 h.p., meaning that the electric light company supplying him has to provide that amount of plant capacity for that particular customer. Allowing for the losses in the generation, transmission, etc., of the current, this means about 10 h.p. capacity in boilers, engines, generators, transmission lines and transformers, in order to finally deliver 7.37 h.p. on the customer's premises. Now it costs a lot of money to built electric light plants, so we will say, for illustration, that the pro rata plant capacity required in this case represents an investment of $2,000. Interest has to be paid on this amount and also a sum set aside each year to cover the item of depreciation.

Electric light companies using the demand system of rates figure that they must get out of their customer this interest and depreciation first, and enough to cover the operating expense and profit afterward. Therefore the first hour, hour and a half or two hours' use (it varies with different companies) of the 50 amperes, or 7.37 h.p., is charged for at a rate to cover all these expenses.

If, for example, the electric light company charges the maximum rate for the first hour use of the demand, and the customer uses the 50 amperes only one hour a day, that means the plant remains idle 23 hours; hence for the one hour's use he must pay enough to cover the interest and depreciation on the plant capacity required for 24 hours. If, however, he continues to use the 50 amperes after the end of the first hour, he is entitled to a lower rate, for he has already paid the interest and depreciation for the 24 hours, and now his rate should only cover the operating expenses and profit charges. That is why a short hour customer pays a higher rate, and is less desirable than the long hour customer.

For example: One man uses 10 amperes at 110 volts for one hour, $10 \times 110 \times 1 = 1100$ watt hours. Another man uses one ampere at 110 volts for 10 hours, which is $1 \times 110 \times 10 = 1100$ watts. They both consume the same wattage, but the first man uses his plant capacity only one hour while the other fellow uses his 10 hours, therefore the latter is entitled to a lower rate, for the reason that the company is not obliged to install added machinery capacity, except for one ampere in the second case, whereas in the first, the machinery capacity must be for 10 added amperes, although that added capacity is only in use for one hour out of the 24 hours, and lying idle the rest of the time.

It is obvious that the average user of electricity does not use exactly the same amount all the time, hence the need of a demand meter. It would be unjust to charge the maximum rate on a demand which was only momentary, therefore the Wright Demand Meter is so designed that the load must stay on for five minutes or more in order to be registered.

In this connection, it will pay the exhibitor to note the difference between choke-coils and tranformers, described elsewhere. If he is paying for current on the demand system, he should never use a choke-coil as a current saver in connection with his moving picture machine.

SEATING

The seating of a theater is, of course, a matter of much importance, particularly if it is a house where the program is of considerable extent. A seat need not be of the best and most comfortable type if the patron is only to occupy it for a matter of some 45 or 50 minutes. If, however, he is to remain seated for two or three hours, then it is essential that the seat be of the most comfortable form; that it be of sufficient width and that there be plenty of room between the rows.

The distance between rows (from chair back to chair back) required by Chicago law is sufficient; also it is none too much. This distance is 32 inches, measuring from top of the back of one chair to the top of the back of the next one ahead.

As to the width of the chairs themselves, it may be 18, 20 or 22 inches; but the 18 inch chair should only be used in houses of very limited seating capacity, since they are too narrow for a corpulent person to sit in, with any degree of comfort; also they are too narrow to be very comfortable for even the average patron. On the other hand, the 22 inch chair is too wide for the average moving picture theater, in which the program is usually not long. This chair is designed rather for the regular dramatic house where the program lasts from two and a half to three hours. The 20 inch chair is about the proper thing for the average moving picture theater.

Upholstered chairs are not desirable, unless the upholstery be leather. Leather upholstery, however, is expensive and, except for 'show purposes" unnecessary, since a non-upholstered opera chair of good design is perfectly comfortable; in fact, in the summer time when one only sits in it, say one hour, it is more comfortable than the upholstered chair, even though the same be leather. Aside from the cost, however, the expense of cleaning upholstered chairs is very much greater than where the non-upholstered type is used, and the deterioration is far greater; so that we may sum this whole matter up by advising the use of ordinary non-upholstered wooden opera chairs of as good a grade as can be afforded.

Such chairs may be had ranging in price all the way from \$1.25 to \$7.00 per chair. The firms, advertising in the Moving Picture World, will supply full and complete data as regards prices, etc., upon request. Excellent chairs can be had for \$1.50 each. By advertising in the Moving Picture World bargains in second hand chairs may sometimes be had.

To figure the seating capacity of a room, or auditorium, is a comparatively simple matter, provided the rows be of equal length and the space between the rows be the same all over the house. For the ordinary hall (store room), the method is as follows: Measure the full length of the room; also its full width. Subtract from the length the distance from the back of the first row of chair backs to the front wall, and the distance from the back row of chair backs to the back wall, which leaves the actual space available for seats. Resolve this result to inches, divide this by 32, and to this result add one row. The result is the number of rows of chairs you can place in the room; the rows being spaced 32 inches apart. Now from the total width of the room, subtract the total width of all aisles, which gives us the total width available for seats. Example: Suppose we have a room 80 feet long by 50 feet wide, and that we purpose to have one center aisle 4 feet wide, and two side aisles 3 feet wide. Now let us decide to place the backs of the front row of chairs ten feet from the screen (ten feet is too close, but in many houses it is necessary to place the first row that distance), and that we will have four feet of space between the rear wall and the back of the rear row of seats. This will give us an actual seating length of 80 minus $(10+4) = 66$ feet. We are to have 32 inches from chair back to chair back, hence we will have $(66 \times 12'') \div 32'' + 1$ row $=$ 25+, the fraction being 24 inches. We would therefore, have 25 rows of chairs, with 12 feet from screen to first row, or, 26 rows and 9 feet 4 inches from screen to first row. We add one row because we are counting points, not spaces.

Our room is 50 feet in width, and we are to have two three-foot aisles, and one four foot aisle. Our total width of seating space therefore, would be $50 - 10 = 40$ feet, which same would be divided into two sections, 20 feet on either side. Now suppose we are to use 20 inch chairs, $20 \times 12'' = 240'' \div 20'' = 12$ exactly, so that we shall have 12 chairs on either side, or 24 to the row. Now as we have 25 rows, our total seating capacity will be $24 \times 25 = 600$. Now if the two sections had been of a little different width: that is to say, if each side had been ten inches more than wide enough to have accommodated twelve chairs, then we could have put twelve chairs on one side and thirteen on the other.

This plan enables one to figure the seating capacity of any plain room in just a few moments. Figuring the seating capacity of a regular theater auditorium is, however, quite a difficult matter, since not only are the rows of different length, but they are also curved. However, the ordinary man will have no occasion to figure such a house, since there will probably be an architect to take care of the matter.

As to the aisles of a theater, due care should be exercised that there be ample passage way to allow of the quick emptying of the theater; but this may be easily carried to unnecessary length. While there is no set plan, which can always be followed, owing to the many different forms of halls, rooms and theater auditoriums, it may, in general, be said there should be no seat sections containing more than fifteen seats unbroken by an aisle, and that all center aisles—that is to say, aisles between sections of seats, should be four feet in the clear, and that all side aisles—that is to say, aisles between side sections and the wall of the room, should be not less than three feet in the clear. It may also be said that where there are side aisles, which do not open directly upon exits other than the main exits, which same are kept unlocked at all times, these aisles should connect with the main entrance by a passage at the rear of the seats, the same to be not less than six feet in width.

The front row of seats should in no event be closer than ten feet from the curtain, and if possible they should be considerably more than that, since the patron seated close to the screen will see a very poor picture indeed, and if he happens to be seated also to one side of the screen, his view will be very bad indeed. Where there is a stage, it is also advisable, unless for some reason it is impractical to have it so, that the screen be located at the rear of the stage, as far away from the audience as possible. This will give those in the front seats a very much better view of the projection, and will not materially affect the view of those in the rear seats, though care must be taken that the screen be not placed so far back that the view of those seated in boxes will be obstructed by the proscenium.

In no case should loose chairs be used—that is to say, chairs not fastened securely to the floor, since should there be an alarm of any kind and the audience start to stampede, loose chairs might, and probably would prove to be a very serious impediment indeed.

SLOPE OF AUDITORIUM FLOOR.

The day of the flat floor is past. Even store room theatres would not now think of attempting to operate with a flat floor. The question is very frequently asked as to what is the best slope to give a floor.

This is a somewhat difficult question to answer, and involves a number of points, all of which must be given due consideration. The steeper the floor, of course, the better view the audience will have of the stage, or the pictures, other things being equal. At any rate the slope should be sufficient to allow a person to see the bottom of the screen over the head of a person seated in the next row ahead. The floor must not be made too steep, however, or steps will be necessary in the aisle, which is objectionable; also if carried to extremes the authorities object on the ground of safety. While the floor slope will necessarially be modified by the length of the theatre or hall, I believe that, in general, a slope of one in ten will be found quite satisfactory. I would advise, however, the floor be given all slope possible without necessitating steps in the aisle.

Where the building is to be erected for theatrical purposes, the architect will, of course, take care of the floor proposition, and where the building is to be remodeled into a moving picture theatre, a floor slope may be obtained in two ways, viz: By dropping the front end of the floor down into the basement, or by building a sloping platform on top of the floor. The former plan is far the better, for several reasons, particularly if the ceiling be low. If a slope is built on top of a floor there should never, under any circumstances, be steps leading up to it from the entrance. The summit of the slope should always be reached by means of another slope, since in case of an alarm of fire or anything else involving a stampede, the audience would pile up on the steps every time, whereas they would probably pass down the slope without any trouble at all. This slope should be carpeted with heavy coarse matting, securely nailed down.

All theater aisles should be covered with some sort of deadening material. For this purpose there is available linoleum and cork matting of various grades, as well as fiber matting and carpet.

Of these various floor coverings, carpet may be discarded entirely, since it catches a very great amount of dirt and wears out quickly. Linoleum is excellent provided there be not much slope to the floor, but if the floor be steep then it is too smooth to be a desirable covering. This leaves the choice between cork matting and coarse fiber cocoa matting for steep aisles, and I believe there can be little question as to which is best. The cocoa matting, if firmly secured to the floor, will prevent slipping; also it will serve as a regular dirt reservoir. It should be taken up every day and the floor, as well as the matting itself thoroughly cleaned. Cork matting of good grade is expensive, but it forms an ideal floor covering in that it prevents slipping, is a good sound deadener, is handsome in appearance, and is clean and sanitary. It may be attached firmly to the floor and allowed to remain there permanently.

AIRDOMES

Of late years, so called "airdomes" or open air theaters are becoming a very popular thing during the summer months, and they are justly popular too, for the reason that it allows of the amusement of the people under the best possible conditions as to, fresh air, etc. There is, however, room for immense improvement in the matter of airdome theaters. As the thing is now, except in a few cases, bad weather has the effect of closing the place, which could be obviated by a combination airdome and winter theater.

Briefly the items to observe in the selection of a site for an airdome are as follows: (a) Will the resultant noise and the glare of light, or the sounds of music call forth protest from the surrounding property owners? If so, just how much wiil their opposition amount to, should be carefully calculated. (b) Does the ground lay right—that is to say, is the lay of the ground adapted to use as a theater auditorium without too much expense of grading? (c) Will it be necessary to erect a high fence all around the place, or is a portion of it already taken care of by bill boards or walls of other character? (d) Does the ground adjoin a large tenement house, or other building having a great many windows from which a good view of the show can be had without the formality of paying an admission? (e) It is necessary to secure signatures of adjoining property owners in order to get a license, and if so can this be done? (f) What will be the probable patronage as judged by the character of the surrounding neighborhood, and the density of its population?

The points to be carefully considered in the erection of an airdome are: (a) The shutting off of the view of the screen as much as possible from the windows of adjoining tenement houses, since too good a view of the screen from such windows frequently operates to materially reduce the box office receipts. Not only will the occupants of the flats see the show without paying an admission, but they will cordially invite their neighbors to go to the theater by their window route. (b) The location of the shading of the screen in such manner that it will not be materially effected by moonlight; also in such position that it will receive the benefit of darkness at the earliest possible hour. In this connection, it must be considered that it will very likely be from 20 minutes to one-half hour later before a picture can be projected on a screen which faces the west, than on one which faces the east.

In order to protect the screen from the effects of moonlight it should be covered by a hood, and protected by flaring wings on either side, both the hood and the wings being not less than ten feet wide, and painted a dead black. This will serve to make the picture much sharper and brighter, and the black should be brought in so as to outline the picture, and so that the picture will lap over on the black outline by two or three inches, sides, top and bottom; (see page 338). A careful observance of this latter will very greatly improve the projection in airdomes. Inasmuch as the audience at an airdome seldom or never sits higher than the screen, the hood need not slope upward much. Perhaps three feet in ten, certainly not more than that. The wings should flare out at an agle of about 60 degrees.

The airdome should be either cemented or floored with lumber, since the dirt floor is by no means satisfactory, particularly to ladies wearing white skirts. The cinder floor is an improvement, but the only right thing (if it pays to do a thing at all, it pays to do it right) is either cement or lumber for flooring.

An effective scheme for airdome work is to have a space back of the regular seating, in which are placed tables for the serving of soft drinks, ice cream, etcetera.

The seats of an airdome should be of a character which, while comfortable, still will not be seriously affected by the weather, since they will of necessity be exposed both to rain and sunshine A carefully made settee is perhaps best; that is to say, a settee made of lumber and divided into seat divisions 20 inches wide. Such a bench can be made by a competent carpenter, but it should be made of slats and formed on the contour of an opera chair. The seats, whatever their character, should be firmly fastened to the floor.

CHEAP EQUIPMENT

As a general proposition it may be said that cheap equipment is very expensive equipment in the end. Except where the use is strictly temporary it seldom or never pays to buy cheap projection apparatus.

The wise manager will keep constantly before him the fact that his energies should be directed first and foremost to the bringing in of every possible penny at the box office, and that if a three hundred dollar projector will, by the added excellence of projection, bring in an added box office revenue of even so much as three dollars per week, as against a projector costing two hundred dollars, then the high-priced machine is emphatically the best investment. He must bear in mind the fact that if one of the lenses is producing poor results, those results will operate to send patronage to some rival house, hence it should be replaced immediately. He should not for one instant forget the fact that his audience pays an admission to his house to see what is spread forth upon his screen, and that the more excellent the performance, the more people will pay admission—hence the greater will be the revenue of the house.

If an experienced thirty-dollar-a-week operator, working with a three-hundred-dollar projector, can produce results sufficiently superior to those produced by the fifteen dollar operator working with a two hundred dollar projector to bring in an added average revenue of let us say forty dollars per week, then the thirty dollar operator and the three hundred dollar projector is a good investment. And if the average increased revenue amounts up to fifty or to seventy-five dollars per week (not at all impossible, or even improbable), then the high-priced outfit is indeed a splendid investment.

COLORING INCANDESCENT LAMPS

It is often desirable to color incandescent globes. Red lamps are needed for exit lights and red, blue and green are used for stage effects. To produce the desired colors dissolve one ounce of refined gelatine in one pint of water, and, after bringing it to a boil, add an aniline dye (Diamond dyes are excellent for the purpose), of the color desired, in sufficient quantity to make the liquid very dense in color. Dip the lamps in the solution while it is hot, and, after removal let them dry as quickly as possible. Repeated dippings and dryings will make the color on the globe more dense. The lamp may then be dipped in a thin brass lacquer, or, better yet, in formaldehyde, which will render the color waterproof. Incandescent globes may be frosted by dipping them in a strong solution of hydrofluoric acid.

MUSIC

The musician is a very important part of motion picture exhibition, and his work can very largely enhance or very largely detract from the excellence of a presentation. There is now a decided demand for improvement in the work of the moving picture theater musician or orchestra. Space to go exhaustively into the subject of music for the moving picture would require a volume by itself. Therefore we can touch upon it here only in a general way. In the columns of the Moving Picture World, Mr. Clarence E. Sinn, of Chicago, ably conducts a department dealing with music for the picture, and from his department those who have kept the files of the Moving Picture World may glean much valuable information on that subject. Of late some of the film manufacturers have been issuing a musical programme for their various subjects. This is very valuable indeed, and the plan should be adopted by all producers.

As to the number of musicians to be employed, that is always and invariably a problem to be met and settled by the individual manager. In thousands of small houses a piano player only is employed. Many small houses use a piano player supplemented by a trap drummer, who usually attempts, with more or less (generally less) success, to make various sound effects. As a rule it would be far better to dispense with the trap drummer and pay a salary sufficient to employ a really good piano player. But whatever is done in the matter of music, one rule should be absolutely adhered to, viz: The music should follow the picture and the music or musician absolutely must not be allowed to speak to anyone during the time a picture is running. How often have we seen a young lady piano player drumming out the music of a topical ragtime song, while at the same time industriously masticating a wad of gum and talking to her "gentleman friend" seated in the front row. The aforesaid topical song serves for the death bed scene or the picnic party. She does not know what is on the screen, neither does she care. Such work is crude, and, to the everlasting credit of progressive managers, is disappearing. Pay your musicians a reasonable salary—a salary sufficient to command excellence—and then demand the best there is in them. If you do not get it from them then, get somebody else.

In closing this topic, let me caution the manager that if he hopes to reap any large degree of success as a manager, he must make a loyal friend of every one of his employees, still he must do this in a way that will not let them for one moment forget the fact that he is "boss."

EMPLOYEES

The wise manager will pay a great deal of attention to the selection of his staff of assistants. The men who make the biggest success in any position of authority, do so not so much by their own personal efforts as by their ability to select efficient help and to command the loyalty of those who serve under them. The theater manager is no exception. If he is a man who makes himself obnoxious; who is grouchy and unpleasant in his intercourse with his employees, he is not likely to have either their respect or their loyalty, and will not succeed in any large way as a manager.

If, on the other hand, he is a man who indulges in horse play, then he will not be likely to command any high degree of respect, and unless employees respect their employer the net result will not be the best. The ideal manager is one who thoroughly understands his business in all its details, and who has the knack of commanding the obedience, respect and loyalty of his employees, without ever speaking a cross word to them. It is not to be expected that this happy faculty will be found in all theater managers, but all managers should strive to approximate it as closely as posible.

I am afraid a great many managers do not realize the importance of securing the loyal devotion and co-operation of their help, and those who do, do not always realize that the faculty of devotion and loyalty does not exist in all men.

Aside from the manager himself, the operator is, of course, the one most important employee in a moving picture theater, since to a very great degree the success of the house will depend upon the excellence of his work. It is quite true that in certain favored locations the five-cent house, or the ten-cent house may do a capacity business with a cheap operator and poor projection. Where this is true, however, the statement can be made without fear of successful contradiction that with a high class operator and good projection the five-cent house could do capacity business at ten cents admission, and the ten-cent house could increase its price and still do capacity business. This is a point that is overlooked by too many managers and is one of the utmost importance. It is not necessary to go into the details of what constitutes excellence in the work of the operator at this time, but merely to point out the fact that where there is business available it does not pay to have anything but the best in the operating room.

The ticket seller should be neatly dressed, preferably wearing at least a uniform cap, and if a lady, it will pay from the dollars and cents point of view to secure one who has a naturally pleasing personal appearance. By "naturally" I mean one who presents a handsome and pleasing appearance without the aid of a mountain of false hair, powder and carmine. She is in a way a part of the "front" of the house, and everything on view from the street should be as pretty as you can make it, but above all things see to it that your ticket seller is minus the usual wad of gum. There may be a time and place for everything, but a girl sitting behind plate glass in a box office, industriously working her teeth on a chunk of gum a half an inch in diameter, certainly adds nothing to the appearance of things. Plainly that is not the time or place for gum chewing.

Little need be said regarding the ticket taker, except that he should be neat and clean in appearance, and by all means uniformed. If there is more or less crowding at the door, it is well to have a ticket taker of goodly proportions and one able to exercise a little diplomacy and common sense in the handling of crowds. Many a dollar has been lost to theaters by ticket takers failing to exercise diplomacy when it became necessary to hold out a crowd. The man with a quick temper has no business in any position where he will be called upon to deal with a mob of people. It is very easy to give offense to a patron, but it is usually a more difficult matter to undo the damage done. I would therefore, advise theater managers to be very careful in the selection of their door-keeper, especially if they are at times obliged to hold out crowds.

Of late the preference in the large city theaters has been very largely toward girl ushers. The New York Hippodrome, the largest theater in the world, employs girl ushers, and has done so for a long time. This example has been followed by many of the Broadway houses, and the experiment has proven entirely successful. The girls are courteous, they are not addicted to the habit of dodging into the smoking room to take a sly draw at a cigarette, and they attend strictly to business; moreover the presence of the girls exercises a certain degree of restraint in language and behavior among the other employees of the house, all of which is good.

Of the stage employees it is hardly necessary to speak, since this work is designed to deal exclusively with moving picture theaters in which ordinarily there are no stage employees. The musicians are mentioned under the heading of "Music."

INSTRUCTIONS FOR VARIOUS MECHANISMS

The instructions for the various mechanisms are calculated to enable the operator to perform any operation which may at any time be necessary. By means of the photographs and system of numbering the parts, it is hoped and believed that the method of removing and replacing, or adjusting various parts of the machine will be made so plain and simple that even the inexperienced man will have little trouble in understanding and following the instructions, whereas the experienced operator will be greatly aided when called upon to take charge of a mechanism, which is new to him.

At first glance, the various instructions may seem somewhat complicated. They are, in fact, very simple, and easily followed. In this connection it must be remembered that the operator seldom has occasion to use more than one of the instructions at a time, while some of them will be used very rarely, and perhaps not at all.

The numbers refer to parts and plates, thus: 678, P 7, means that part 678 will be found on plate 7. 682, P 3 and 5, means that part 682 will be found on both plates 3 and 5.

Instructions for the leading makes of machines will be found on the following pages: Edison Kinetoscope, 229; The Motiograph, 244; Power's Cameragraph, 270; The Simplex, 291; The Standard, 305.

Glossary

ABBREVIATIONS

For the sake of brevity certain abbreviations have been used in this work. They are explained as follows:

A. C.—Alternating Current.
D. C.—Direct Current.
stereo—Stereopticon.
k.w.—Kilowatt.
e.f.—Equivalent Focus.
b.f.—Back Focus.
Fahr.—Fahrenheit.
Cent.—Centigrade.
h.p.—Horsepower.
c.p.—Candlepower.
r.p.m.—Revolutions per minute.
c.m.—Circular Mills.

DEFINITIONS

Alloy—Any compound of two or more metals, as of copper and zinc, which form brass.

Alternator—An alternating current dynamo.

Ammeter—An instrument by means of which the strength of current is measured in amperes.

Ampere—See pages 14-16.

Amperage—The number of amperes passing through a circuit.

Volt-Ampere—The same as watt.

Anode—The positive pole of an electric battery, or, preferably, the path by which the current passes out and enters the electrolyte on its way to the other pole. Opposed to cathode.

Arc—The stream of hot gases and particles of carbon, metal, or other substances visible between two separated parts of a circuit.

Arc, Hissing—A term applied to the arc which produces a hissing sound due to too close approach of the carbon points.

Armature—A body of iron or other material susceptible to magnetization, which is placed on or near the poles of a magnet. That part of a dynamo in the coils of which the current is generated.

B. & S.—An abbreviation of Brown & Sharp's wire gauge.

Candlepower—The amount of light given by a standard flame which consumes two grains of sperm wax per minute.

Capacity—A term used when speaking of the carrying power of a wire, or circuit. The capacity of a wire is sufficient so long as the current does not appreciably heat it. As soon as electric heat is generated, we speak of the wire as being overloaded, which means its capacity is overtaxed.

Cathode—That part of a battery by which the current leaves substances through which it passes, or the surface at which the electric current passes out of an electrolyte. The negative pole.

Short Circuit—A connection between two parts of a circuit, allowing the current to skip a part of its appointed path.

Commutator—An arrangement which connects the wires of a circuit with a revolving armature.

Coulomb—The practical unit of electrical quantity. It is the quantity passed by a current of 1 ampere intensity during one second.

Cycle—Events following each other in succession, recurring periodically. Twice the number of alternations A. C. makes per second.

Efficiency—The ratio of useful work to energy expended.

Field, Electromagnetic—A certain space surrounding every electro-magnet or conductor carrying alternating current, which is charged with lines of electro-magnetic force.

Graphite—A condition of carbon in which it has soft lustre, and possesses high lubricating qualities.

Ground—A term applied to the connections of a wire to the earth so that the earth becomes a full or partial return circuit.

Horsepower—A unit of a standard by which the capabilities and rate of doing work is measured, estimated as 33,000 pounds raised one foot in one minute.

Incandescence—The glowing whiteness of a body owing to intense heat. The condition of a carbon crater or lamp filament when at candlepower.

Induction—The influence exerted, without apparent communication, by a magnetic field or a charged mass upon neighboring metallic bodies.

Induction, Electro-magnetic—A kind of electro-dynamic induction wherein, by the motion either of electro-magnets or electro-magnetic solenoids, electric currents are obtained.

Insulation—The application or employment of any material or medium by means of which electricity is prevented from entering into or escaping from the body insulated.

Joule—The practical unit of electric energy, which is equal to .73734 of a foot point, or .00134 of a h.p. per second. The quantity of electric work necessary to raise the potential of one coulomb of electricity one volt.

Lead—An insulated conductor which leads to or from a source of power.

Ohm—See pages 15-17.

Over-Compounded—Compound winding on dynamo of such character that the voltage at its terminals is caused to increase under a greater load.

Potential—That affinity which one wire of an electric circuit has for the other; the higher the voltage the greater the potential.

Resistance—That property of an electric conductor which opposes the passage of electric current.

Shunt—To establish a connection in parallel (multiple) with a portion of the circuit.

Tape, Insulating—An adhesive tape of flexible material, saturated with rubber, okonite, or other insulating substances, and used to effect insulation on the wire ends, etcetera.

Terminals—The poles or electrodes of a battery; also applied to the connections of various electric devices, such as switches, etcetera.

Volt—See pages 14-16.

Voltmeter—An apparatus employed to measure the pressure of electric current.

Watt—See pages 15-17.

Wattmeter—An instrument by means of which the amount of power used is measured.

Wire, Dead—A wire which has no voltage.

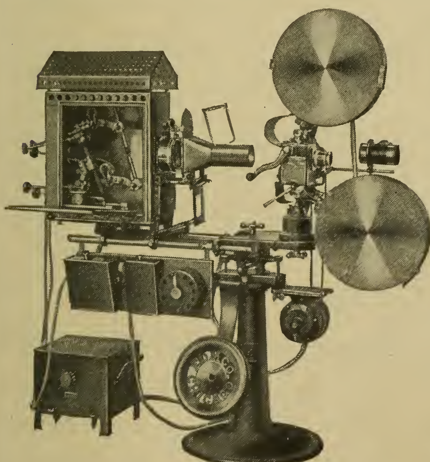
Wire, Live—A wire through which current is flowing, or which is connected to the active source of electric power; a wire that possesses voltage.

Motiograph Quality

HAS NEVER BEEN QUESTIONED

WE WANT YOU to compare THE MOTIOGRAPH with any machine selling near the same price.

WE WANT YOU to learn that WE USE NO COMPOSITION METAL IN OUR CONSTRUCTION—IT IS NOT GOOD ENOUGH to match up to the HIGH STANDARD QUALITY which has so firmly established the reputation of this machine.



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